

FALMOUTH, MASSACHUSETTS



LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED MARCH 18, 1964, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A COOPERATIVE BEACH EROSION CONTROL STUDY OF FALMOUTH, MASSACHUSETTS, AUTHORIZED BY THE RIVER AND HARBOR ACT APPROVED JULY 3, 1930, AS AMENDED AND SUPPLEMENTED



**JULY 20, 1964.—Referred to the Committee on Public Works
and ordered to be printed with three illustrations**

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U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1964

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LETTER OF TRANSMITTAL



DEPARTMENT OF THE ARMY
WASHINGTON 25, D.C.

IN REPLY REFER TO:

June 26, 1964

Honorable John W. McCormack
Speaker of the House of Representatives

Dear Mr. Speaker:

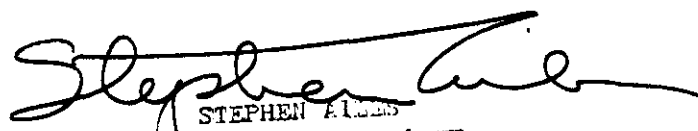
I am transmitting herewith an unfavorable report dated 18 March 1964, from the Chief of Engineers, Department of the Army, together with accompanying papers and illustrations, on a cooperative beach erosion control study of Falmouth, Massachusetts, authorized by the River and Harbor Act approved 3 July 1930, as amended and supplemented.

The views of the Massachusetts Department of Public Works, the Commonwealth of Massachusetts and the Department of the Interior are set forth in the inclosed communications.

The Bureau of the Budget advises that there is no objection to the submission of the proposed adverse report to the Congress. A copy of the letter from the Bureau of the Budget is inclosed.

✓ In view of the basic data contained therein, it is recommended that this report be printed.

Sincerely yours,


STEPHEN ALLEN
Secretary of the Army

1 Incl
Report

COMMENTS OF THE BUREAU OF THE BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT

BUREAU OF THE BUDGET

WASHINGTON, D.C. 20503

June 3, 1964

Honorable Stephen Ailes
Secretary of the Army
Washington, D. C. 20310

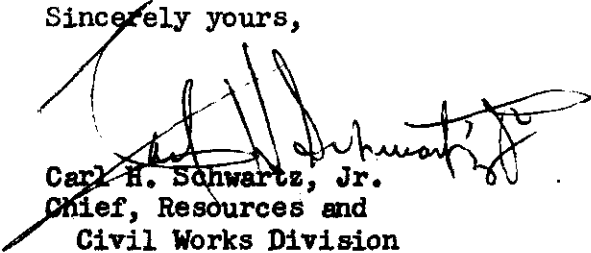
Dear Mr. Secretary:

Mr. Harry C. McPherson's letter of April 30, 1964, submitted the unfavorable report of the Chief of Engineers on a cooperative beach erosion control study of Falmouth, Massachusetts, authorized by the River and Harbor Act approved July 3, 1930, as amended and supplemented.

The Chief of Engineers recommends that the report with selected illustrations be published because of its general interest to the public and its value to local authorities.

I am authorized by the Director of the Bureau of the Budget to advise you that there would be no objection to the submission of the proposed adverse report to the Congress.

Sincerely yours,



Carl H. Schwartz, Jr.
Chief, Resources and
Civil Works Division



The Commonwealth of Massachusetts

Department of Public Works

Office of the Commissioner

100 Nashua Street, Boston 14

March 27, 1964

W. K. Wilson, Jr., Lieutenant General, U.S.A.
Chief of Engineers
Department of the Army
Washington 25, D. C.

Reference:ENG CW-PD

Dear General Wilson:

Thank you for the copy of the report on a co-operative beach erosion control study of Falmouth, Massachusetts.

I have reviewed the subject matter and plans for protecting and restoring the shoreline from Nobsha Point to Waquoit and concur in the findings of your engineers. Of course, we are a little disappointed to learn that the public sections of this shorefront do not qualify for Federal participation in the cost of protection but realize that benefit/cost criteria must be the deciding factor in determining such participation. As indicated in the report, a substantial amount of money, both public and private, has been expended in retarding erosion in this area. Future public protective structures erected by this Division along these shores will be designed substantially in accordance with the recommendation contained in this report.

I wish to congratulate your Division Engineer and his staff for the fine work they have done in compiling this report.

Very truly yours,


FRANCIS W. SARGENT
Associate Commissioner

COMMENTS OF THE COMMONWEALTH OF MASSACHUSETTS



OFFICE OF THE DIRECTOR

The Commonwealth of Massachusetts
Water Resources Commission
73 Tremont Street, Boston 8

March 6, 1964

Robert C. Marshall
Colonel, Corps of Engineers
Assistant Director of Civil Works
for Atlantic Divisions
Washington 25, D. C.

Re: ENG CW-PD

Dear Sir:

Reference is made to your letter of January 21, 1964 requesting comments on the U. S. Corps of Engineers report relative to beach erosion at Falmouth, Massachusetts.

The Water Resources Commission, after considering the report concurs with the conclusions contained therein.

Particular reference is made to the recommendation that any work undertaken by the Commonwealth to control erosion will be undertaken in accordance with the recommendation in the report.

Very truly yours,

A handwritten signature in cursive script, reading "Malcolm E. Graf".

Malcolm E. Graf
Director and Chief Engineer

MEG:im

COMMENTS OF THE DEPARTMENT OF THE INTERIOR



UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

November 21, 1963

Dear General Wilson:

We have reviewed reports on a cooperative beach erosion study of Falmouth, Massachusetts, transmitted with your letter of August 29, 1963.

Your report recommends that because of the insufficiency of public benefits no project be adopted by the United States at this time authorizing Federal participation in the costs of measures for the restoration and protection of the shores of the study area.

This Department has no objection to your conclusions and thanks you for the opportunity of presenting our comments.

Sincerely yours,


Kenneth Holum
Assistant Secretary of the Interior

Lt. General Walter E. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington 25, D. C.

FALMOUTH, MASSACHUSETTS

REPORT OF THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY

HEADQUARTERS
DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D. C.

18 March 1964


SUBJECT: Beach Erosion Control Report on Cooperative Study of Falmouth, Massachusetts.

TO: THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress the report of the Beach Erosion Board, accompanied by the report of the Division Engineer, on a beach erosion study of the shore at Falmouth, Massachusetts, made by the Corps of Engineers in cooperation with the Commonwealth of Massachusetts under the provisions of section 2 of the River and Harbor Act approved July 3, 1930, as amended.

2. The Beach Erosion Board concurs generally in the methods of protection and improvement proposed by the Division Engineer. Because of the insufficiency of public benefits to be expected therefrom, the Board recommends that no project be adopted by the United States at this time authorizing Federal participation in the costs of measures for the restoration and protection of the shores of the study area.

3. After due consideration of these reports, I concur in the views and recommendations of the Beach Erosion Board. Because of their general interest to the public and their value to local authorities, I recommend that these reports with selected illustrations be published.


W. K. WILSON, JR.
Lieutenant General USA
Chief of Engineers

REPORT OF THE BEACH EROSION BOARD

CORPS OF ENGINEERS, U. S. ARMY
BEACH EROSION BOARD
WASHINGTON, D. C.

28 February 1963

SUBJECT: Beach Erosion Control Report on Cooperative Study of Falmouth, Massachusetts

TO: Chief of Engineers
Department of the Army
Washington, D. C.

1. This report is on a study of beach erosion made in cooperation with the Commonwealth of Massachusetts under authority of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The purpose of the investigation was to determine the best method for restoring and stabilizing beaches, and stabilizing bluff areas.

2. The study area comprises the Vineyard Sound shore of the Town of Falmouth between Nobska Point and the east limit of the town at the entrance to Waquoit Bay. The area has a total shore frontage of 7.8 miles, of which about 2.0 miles are publicly owned. The shore area is developed principally for summer recreational use. The population of the town, about 13,100, is increased by about 40,000 during the summer.

3. The shores of the study area are exposed to ocean waves from the east and southwest, but are protected to the south by the island of Martha's Vineyard. Accretion at the west sides of structures indicates a general eastward predominance in the direction of littoral drift. Tides are semi-diurnal, the mean range being about 1.5 feet. The maximum tide of record, 12.7 feet above mean low water occurred during the 1944 hurricane. Tides of 3 feet or more above mean high water occur about once a year.

4. The study area is characterized by headlands of unconsolidated glacial material which have supplied material to the beaches and formed baymouth bars at the numerous indentations in the original shore line. Depletion of available material has reduced the supply and the beaches have gradually deteriorated. Numerous groins and jetties at inlets have compartmented the shore, so that the rate of loss is low. The building and maintenance of adequate beaches may be accomplished by artificial placement of sand. The rate of loss of fill can be further reduced by groins.

5. The Division Engineer has developed plans for restoring and protecting the shores of the area. He concludes that practicable plans which merit consideration for the protection and improvement of shores within the study area are as follows:

a. Nobska Point to Falmouth Beach - Constructing stone mounds or revetment where needed for bluff protection.

b. Falmouth Inner Harbor to Falmouth Heights - Widen 1,000 feet of beach by direct placement of sand fill, lengthen Falmouth Harbor east jetty to 250-foot length, enlarge and lengthen existing groin to 250-foot length.

c. Falmouth Heights Bluffs. - Place additional riprap revetment along the toe of approximately 1,450 feet of wall, place stone revetment on approximately 750 feet of slope above the wall and control surface runoff wherever needed.

d. Mara Vista. - Construct low walls, approximately 1,900 feet long, along the seaward side of the shore road.

e. Acapesket. Widen 1,300 feet of beach by direct placement of sand fill, enlarge and lengthen four (4) existing groins to total lengths of 345 to 510 feet.

f. Davisville. - Widen 1,600 feet of beach by direct placement of sand fill, construct a jetty 530 feet long and two groins 340 and 510 feet long.

g. Menauhant. - Widen 1,600 feet of beach by direct placement of sand fill, construct a low wall 1,500 feet long, enlarge and lengthen three existing groins to total lengths of 240 to 280 feet.

6. The Division Engineer finds that prospective benefits of the plans of protection and improvement considered do not warrant Federal participation in the construction of those plans. Accordingly he recommends that no project be adopted by the United States at this time for the protection or improvement of the shores at Falmouth, Massachusetts.

7. Local interests were informed of the findings and recommendations of the Division Engineer and invited to present additional information for the consideration of the Beach Erosion Board. No communications were received as a result of the public notice.

VIEWS AND RECOMMENDATIONS OF THE BEACH EROSION BOARD

8. The Board has carefully considered the report of the Division Engineer. The Board concurs generally in the methods of protection and improvement proposed therein. However, the Board believes that details of the plans, such as characteristics and sources of sand for beach fills and groin dimensions, should be checked at the detailed design stage and

modified as may be required, based upon field surveys immediately prior to construction. Contingency items in the cost estimates are believed to be sufficient to cover minor design modifications which may be required.

9. In accordance with existing statutory requirements the Board states its opinion that the public benefits involved in the considered measures are insufficient to warrant a share of the expense thereof being borne by the United States. Therefore it is inadvisable for the United States to adopt projects authorizing Federal participation in the costs of protecting the shores of the study area at this time.

10. The Board recommends that no projects be adopted by the United States at this time authorizing Federal participation in the costs of measures for the restoration and protection of the shores of the study area. The Board further recommends that protective measures which may be undertaken by local interests, based upon their own determination of economic justification, be accomplished generally in accordance with methods developed by the Division Engineer.

FOR THE BOARD:



WILLIAM F. CASSIDY
Major General, USA
President

At the time of consideration of this report the members of the Beach Erosion Board were:

Major General William F. Cassidy, President
Dr. Thorndike Saville, State of New York
Dean Morrough P. O'Brien, State of California
Dr. Lorenz G. Straub, State of Minnesota
Brigadier General Arthur H. Frye, Jr., U. S. Army
Brigadier General John C. Dalrymple, U. S. Army
Colonel Peter C. Hyzer, Corps of Engineers, U. S. Army

REPORT OF THE DIVISION ENGINEER

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 Trapelo Road
Waltham 54, Mass.

NEDGW

SUBJECT: Beach Erosion Control Report on Cooperative Study of
Falmouth, Massachusetts

TO: Chief of Engineers
Department of the Army
Washington 25, D. C.

SYLLABUS

This study covers the Vineyard Sound shore of the town of Falmouth, Massachusetts between Nobska Point and the Waquoit Bay entrance. The purpose is to determine the best method of restoring and stabilizing beaches and stabilizing the bluff areas.

The Division Engineer finds that erosion of beaches and bluffs and storm damages to shore roads and the coastal development have occurred from wave attack. A large part of the shore is particularly vulnerable to damages since it consists of low barrier bars subject to overtopping during storms and hurricanes accompanied by high tides. Protective works constructed around Nobska Point since initiation of this study now provide adequate bluff protection for that former problem area.

The Division Engineer has developed practicable plans for protection and improvement of shore areas, as follows:

a. Between Nobska Point and Falmouth Beach. - Construct stone mounds or stone revetment wherever needed for bluff protection.

b. Between Falmouth Inner Harbor and Bluffs at Falmouth Heights. - Widen 1,000 feet of beach by direct placement of sand fill, lengthen Falmouth Harbor east jetty and enlarge existing groin.

c. Falmouth Heights Bluffs. - Place additional riprap revetment along the toe of approximately 1,450 feet of wall, place stone revetment on approximately 750 feet of slope above the wall and control surface runoff wherever needed.

d. Mara Vista. - Construct low walls, approximately 1,900 feet long along the seaward side of the shore road.

e. Acapesket. - Widen 1,300 feet of beach by direct placement of sand fill, enlarge and lengthen four (4) existing groins.

f. Davisville. - Widen 1,500 feet of beach by direct placement of sand fill, construct a jetty and two groins.

g. Menauhant. - Widen 1,600 feet of beach by direct placement of sand fill, construct a low wall 1,500 feet long and enlarge and lengthen three (3) existing groins.

Direct placement of sand fill along the shore or in stockpiles to be distributed by wave action for nourishment of beaches, or reconstruction or relocation of low shore roads at a higher elevation are suitable methods for providing protection or improvement for some locations. Complete protection of low shore areas by high seawalls or other barriers against overtopping during severe storms or hurricanes is not warranted by the limited developments which would benefit.

Since the public interest required by Public Law is insufficient to warrant Federal participation in the cost of construction of the projects considered, the Division Engineer recommends that no project be adopted by the United States for the protection or improvement of the shores of Falmouth, Massachusetts. It is further recommended that protective measures which may be undertaken by local interests, based upon their determination of economic justification be accomplished in accordance with plans and methods considered in this report.

BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF

FALMOUTH, MASSACHUSETTS

PART I-GENERAL

1. Authority. - This study was made by the Corps of Engineers, United States Army, in cooperation with the Division of Waterways of the Massachusetts Department of Public Works under Authority of Section 2 of the River and Harbor Act approved 3 July 1930 as amended and supplemented. The formal application for the study dated 12 February 1959, was approved by the Chief of Engineers on 26 March 1959.

2. Purpose. - The purpose of the study as stated in the formal application is to determine the best method of restoring and stabilizing beaches and stabilizing the bluff areas.

3. Prior Reports. - There have been no prior beach erosion control reports covering the study area. There have been reports on navigation studies at Falmouth Harbor within the study area and at Woods Hole adjacent to the study area which resulted in adoption of Federal navigation projects.

4. Description. - The study area is in Barnstable County along the south or Vineyard Sound shore of the town of Falmouth between Nobska Point and the east limit of the town at the Waquoit Bay entrance. It is approximately 74 miles south of Boston, Massachusetts and 39, 53 and 63 miles, respectively, east of New Bedford and Fall River, Massachusetts and Providence, Rhode Island. The location is included on United States Coast and Geodetic Survey Charts 1209, 259 and 249, on the Onset and Falmouth Quadrangles of the United States Geological Survey and on Plate 1 of this report.

5. The permanent 1960 population of Barnstable County was 70,826 and of the town of Falmouth was 13,077, each approximately 50 percent higher than in 1950. The population of the town of Falmouth is increased about 40,000 during the summer.

6. The study area is 7.8 miles long of which approximately 2.0 miles are owned by the town of Falmouth and 5.8 miles are privately owned. The town property consists of 0.24 mile of revetted bluff bordering the shore road at Nobska Point, 0.26 mile of narrow beach fronting the railroad right-of-way west of Oyster Pond, 0.46 mile of public bathing beach bordering Surf Drive east of Salt Pond, 0.65 mile of public bathing beach at Falmouth Heights, street ends at Davisville and 0.35 mile of public bathing beach at **Menauhant**. All but the easterly 1.1 miles of shore are accessible over State, town

or private roads. Much of the shore is closely paralleled by town roads. Washburn Island, containing the easterly 1.1 miles of shore is completely surrounded by water and can be reached only by boat.

7. Development along the shore consists of a United States Coast Guard Station at Nobska Point, widely spaced residences between Nobska Point and Oyster Pond, small summer cottages on the beach fronting Salt Pond, and residences, inns, and other seasonal accommodations behind the beach east of Salt Pond to Little Pond with the development extending about one mile inland encompassing the business section of the town along Highway Route 28, and a commercial section of the town around Falmouth Harbor associated with boating and fishing. Residential development, largely seasonal, also exists along the shore to the east of Little Pond at Mara Vista, Acapesket, Davisville and Menauhant. The shore of Washburn Island and most of the low barrier bars or spits fronting Eel, Bournes, Green, Great and Little Ponds are undeveloped. More detailed descriptive information concerning the development and composition of beaches is included in Appendix A. Bacterial tests of samples of water from the beaches indicate that the usability of the beaches is not impaired by pollution which would endanger the health of bathers.

8. Statement of the Problem and Improvement Desired. - The problem consists of erosion of bluffs and beaches and storm damages to shore roads and the coastal development from wave attack. At the time of application for the study, the serious erosion of the bluff at Nobska Point and the rapid erosion and loss of beach fill placed along the west end of the Falmouth Heights public beach from the dredging of Falmouth Harbor in 1957 were of greatest concern. Erosion and storm wave attack constitute problems along the entire study ~~areas~~ as indicated by the numerous groins, jetties, stone mounds, walls and revetments which have been constructed for protection of beaches, roads, cottages, residences and inlets. A large part of the shore is particularly vulnerable to damages since it consists of low barrier bars which are subject to overtopping during storms and hurricanes accompanied by high tides. Such areas front Oyster, Salt, Little, Great, Green, Bournes and Eel Ponds. The shore development is generally concentrated on low land behind the beaches between the ponds and it is subject to damages from overtopping of the beaches and erosion of the land. Erosion of the bluff at Falmouth Heights endangers the shore road. Protection against the former serious erosion of the bluff at Nobska Point was provided by construction of a stone mound and riprap slope protection during 1959.

9. The needs and views of the cooperating agency and town officials concerning protection and improvement of the shores were obtained through correspondence and meetings during the conduct of the study. A joint meeting was held on 3 August 1962 attended by the engineering representative of the cooperating agency, the Town

Selectmen, the Town Engineer and members of the Town Waterways Committee at which shore problems and methods of protection were discussed. Suggestions by local interests were made as follows:

a. Maintenance of the shore could be effected by periodic placement of sand in stockpiles at locations from which the sand would be transported eastward by littoral currents to nourish the beaches thereby preventing their continued erosion and recession. This method would require the use of jetties or other littoral barriers at the west sides of inlets to impound the drifting sand. Separate stockpiles would be needed for physiographic units of shore between inlets.

b. The east jetty at Falmouth Inner Harbor could be lengthened to reduce loss of beach sand from the Falmouth Heights shore and consequent shoaling of the Falmouth Inner Harbor entrance.

c. Reconstruction of the highway bridge over the Bournes Pond Inlet and the shore road along Menauhant Beach east of the bridge is needed to permit adequate protection against recurring storm damages. The bridge and road should be rebuilt at a higher elevation at a location farther landward than at present. There is publicly owned land available on which the bridge and road could be relocated.

d. Methods of keeping the Siders Pond drainage culvert open are desired. A sandy barrier bar forms between the two existing stone jetties which flank the culvert and this blocks the drainage.

PART II - FACTORS PERTINENT TO THE PROBLEM

10. Geomorphology. - The shore line consists mostly of marine deposits in the form of a chain of sandy baymouth bars fronting ponded erosional furrows or kettle holes. It is situated on the sea margin, about 12 miles south of the apex of a triangular plain composed largely of stratified sands grading surficially from coarser near the apex to finer at the base. The apex is at the Cape Cod Canal at the intersection of two terminal moraines, one extending southwestward paralleling the Buzzards Bay shore to Nobska Point, the other southeastward paralleling the north or Sandwich shore of the inner arm of Cape Cod. The chain of baymouth bars extends eastward from the protruding glacial till headland at Nobska Point to a glacial till hill at Falmouth Heights and thence eastward, generally as a smooth shoreline to the terminus of the study area at Waquoit Bay, interrupted by inlets to the tidal ponds. A more detailed description is contained in Appendix B.

11. Littoral Materials. - a. Characteristics. - Character of littoral materials was determined from surface samples taken along seven (7) beach profiles spaced throughout the study area. The results of the sample analyses are included in Appendix C. Determination of character of materials at selected profiles and in Falmouth Inner Harbor, Great, Green, Bournes and Eel Ponds, and Waquoit Bay was made by probings. Locations of probings and material encountered are shown on Plates 2, 3 and 4. General descriptive information concerning composition of beaches, obtained by visual inspection, is included in Appendix A. The samples indicated that littoral materials consisted principally of medium sand along the easterly portion of the study area at Washburn Island, Menauhant and Acapesket, medium and fine sand in the central portion at Falmouth Heights and Falmouth Public Beach at Surf Drive and gravel, medium and fine sand along the western end of Falmouth Beach. At Nobska Point it consisted of gravel above low water and medium and fine sand below low water. Considerable quantities of gravel existed on all profiles, the largest amounts in the onshore part of the profiles at the ends of the study area and in the offshore part in the central area. Probings in Falmouth Harbor, the ponds and Waquoit Bay indicated that the material consisted of layers of mud and sand. Probings in the offshore on Profiles 2, 8, 16, 18, 20 and 22 indicated that the material consisted of sand and gravel with some mud at Profile 8. Only a small amount of penetration to refusal or hard sand was obtained on the offshore probings.

b. Sources. - Glacial deposits constitute the principal source of beach materials. Materials eroded from the glacial till headland at Nobska Point, the glacial till hill at Falmouth Heights and from the sandy deposits comprising the prongs between the bays and ponds have been transported by littoral currents and have formed the existing beaches. These original sources of beach building materials have been largely eliminated by the construction of protective works. Placement of fill along the shore from the dredging of harbor and pond improvements has in recent years constituted an important source of material. Samples and probings and experience with dredging operations indicate that sources of material suitable for nourishment of beaches by hydraulic dredging exist in the ponds and bays and in Vineyard Sound.

12. Littoral Forces. - a. Waves. - The shoreline is directly exposed to waves from the Atlantic Ocean through the four mile wide Vineyard Sound opening to the southwest, the ten mile wide Nantucket Sound opening between Monomoy Point and Nantucket Island to the east and the seven mile wide Nantucket Sound opening between Martha's Vineyard and Nantucket Island to the southeast. Wave sizes from these directions are reduced considerably by the limited fetch width through Vineyard Sound and by the shoals at the Nantucket Sound

entrances. The shoreline lies in the lee of the mainland from the north and northeast and to a lesser extent from the west. Martha's Vineyard, four miles to the south and Nantucket Island and Monomoy Island 30 miles to the southeast and east, respectively, provide some shelter from these directions. No wave measurements are available for the immediate area. A wave rose based on synoptic weather charts prepared by the Beach Erosion Board for a deep water location off Nauset Beach, Cape Cod, Massachusetts is shown on Plate 1. It indicates that waves off Nauset Beach occur with greatest frequency from the northeast and east and that waves from the southerly directions, to which the shoreline is more directly exposed, occur with a considerably lesser frequency.

b. Currents. - Tidal currents flood to the east and ebb to the west. Maximum average velocities in Vineyard Sound one mile south of Nobska Point are 2.6 and 2.4 knots on the flood and ebb, respectively. In Nantucket Sound, about midway between the mainland and Martha's Vineyard, average velocities are 2.1 and 2.2 knots on the flood and ebb, respectively. Tidal currents at Falmouth Harbor, the ponds and Waquoit Bay flood northward into the inlets and ebb southward out of the inlets.

c. Winds. - Records of winds observed by the United States Weather Bureau at Nantucket, Massachusetts for a five-year period from August 1952 to July 1957 and a two-year period from August 1958 to July 1960 show that winds blow from westerly directions about two-thirds of the time and from easterly directions about one-third of the time. Onshore winds from the southwest quadrant have a slightly longer duration than from the northwest quadrant and double the duration of onshore winds from the southeast quadrant. A wind diagram based on the observed data is shown on Plate 1. A summary of the data and a more detailed description is included in Appendix D.

d. Storms. - Analysis of nine years of United States Weather Bureau records, consisting of three separate periods from 1945 to 1960, was made for winds having a continuous duration of at least four hours and a wind speed of 30 miles per hour or higher. It showed that north northeast winds occur most frequently and have the longest duration, that northeast and east northeast winds have the highest average speeds and that winds have the longest duration from the northeast quadrant. It also showed that winds have the shortest duration from onshore directions from the southeast and southwest quadrants and that winds from the southwest quadrant have a much longer duration than from the southeast. A summary of these winds is included in Appendix D, Table D-2.

e. Tides. - Tides are ~~semi-diurnal~~. The mean ranges are 1.5 feet at Nobska Point, 1.3 feet at Falmouth Inner Harbor

and Falmouth Heights and 1.1 feet in Waquoit Bay. Spring ranges are 1.9 feet at Nobska Point and 1.6 feet at Falmouth Heights. The highest tide of record of 12.7 feet above mean low water occurred at Falmouth Heights during a hurricane on September 14-15, 1944. Tides 3.0 feet above mean high water probably occur about once a year. More detailed information concerning tidal observations, frequencies of occurrence and extreme tides is included in Appendix E.

13. Shore History. - a. Shoreline Changes. - High water shoreline changes during the entire period of record from 1845 to 1961 were smaller along the study area west of Falmouth Inner Harbor than to the east. There was little change at the outer tip of Nobska Point and erosion and varying amounts of shore recession, not exceeding 100 feet, along most of the shore to the east to and including Falmouth Beach except for localized areas at the west sides of groins and similar structures where impounded material caused short segments of the shoreline to move seaward. Recession of the shore, generally less than 50 feet, occurred along the shore between Falmouth Beach and Falmouth Inner Harbor except adjacent to the west Falmouth Harbor jetty where impounded material moved the shore up to about 200 feet seaward. The Falmouth Heights shore was eroded between 1845 and 1941 resulting in landward shore movements of up to about 150 feet but during 1961, as a result of direct placement of sand on the beach during 1957, and subsequent drifting, parts of this shore were up to about 150 feet seaward of their 1941 position. From 1845 to 1961, the Mara Vista shore moved 50 to 100 feet landward, the Acapesket shore receded 150 to 500 feet, the greater recession along the easterly third of the area, the Davisville shore receded 100 to 400 feet, the larger movement at the west end, the Menauhant shore receded 100 to 250 feet and the Washburn Island shore moved landward along its west half up to about 700 feet and the shore along the east half moved seaward up to about 500 feet, the latter accretion as a result of impounding of material at the Waquoit Bay west jetty. Changes in recent years (from 1938-1942 to 1961) have been influenced by the construction of various types of protective works. Large or significant changes during this period have consisted of accretion at the west sides of groins between Nobska Point and Falmouth Beach, at the west side of the Falmouth Inner Harbor west jetty, along most of the Falmouth Heights shore, at the west side of the Waquoit Bay west jetty and recession at the east and west ends of the Acapesket shore and at the west end of the Washburn Island shore at the Eel Pond entrance.

b. Offshore Depth Changes. - Movements of offshore depth contours were irregular and of a magnitude to indicate that offshore depth changes were generally small. Changes in the vicinity of various depths were as follows: Plus signs indicate shoaling and minus signs deepening.

Location	Period	DEPTH			
		6-Foot	12-Foot	18-Foot	30-Foot
Nobska Point	1938-1961	No significant changes			
Nobska Point to Falmouth Beach	1887-1938	+	+	-	-
	1938-1954	No significant changes			
	1954-1961	+	+	+	+
Falmouth Beach	1887-1938	-	-	+	+
	1938-1961	No significant changes			
Falmouth Beach to Falmouth Hbr	1887-1961	-	-	-	-
Falmouth Heights	1845-1938	-	-	+	+
	1938-1961	-	-	-	-
Mara Vista	1845-1938	-	-	+	+
	1938-1961	-	-	-	No change
Acapesket	1845-1938	-	-	-	+
	1938-1961	-	No change	+	+
Davisville and Mensauhant	1845-1931	+	+	+	+
	1938-1961	-	+	+	No change
Washburn Island	1845-1938	No information			
	1845-1961	No change	-	+	+

c. Prior Corrective Action and Existing Structures. ~

Many protective works have been constructed throughout the study area over a long period to prevent erosion of beaches and bluffs, to prevent storm damages, to restore losses of beach materials and to stabilize inlets. Structures consist of the following: a stone mound, slope revetment and groins of Nobska Point; stone walls, revetment and groins and timber bulkhead and piers between Nobska Point and Falmouth Beach; stone groins, jetties, breakwaters and revetment, timber piers and a concrete and steel bulkhead at Falmouth Beach; stone mounds, walls, groins and revetment and concrete groins and walls between Falmouth Beach and Falmouth Inner Harbor; stone jetties at the entrances to Falmouth Inner Harbor, Little Pond, Great Pond, Green Pond, Eel Pond, and Waquoit Bay; mortared and dumped stone revetment, stone and concrete groins and concrete walls at Falmouth Heights; stone groins and revetment, concrete walls, timber groins, bulkhead and piles at Mara Vista; stone groins, revetment and mound, precast concrete block wall

and timber piles and bulkhead at Acapesket; stone groins, mounds and revetment, timber groins, bulkheads and piles, and concrete groins at Davisville; stone groins, revetment and mound and timber bulkheads and groins at Menauhant; stone groins at Washburn Island. Sand fills have been placed west of the Falmouth Harbor entrance, along Falmouth Heights, Mara Vista, Acapesket and Menauhant. More detailed information concerning these structures and beach fills is included in Appendix G. Existing structures are shown on Plates 2, 3, and 4.

d. Beach Profiles. - Beach profiles were surveyed during 1961 at twenty-four selected locations throughout the study area as shown on Plates 2, 3, and 4. Plots of the profiles are shown on Plates 5 to 8, inclusive. A more detailed description of the profiles, a tabulation of the slopes on individual profiles and their principal characteristics at the various beaches is included in Appendix H. Due to lack of comparative surveys, seasonal changes of beach slopes could not be determined. There were large and irregular variations of beach slopes along the shore. Heights of beach berms above the plane of mean low water, where they existed were as follows: Washburn Island, 6.5 feet; Falmouth Heights between 5.0 and 6.0 feet; Falmouth Beach 6.5 feet; and between Nobska Point and Falmouth Beach, 6.0 feet. The steeper portions of the profiles seaward of the berms or upper portions of the beaches to below low water had slopes as follows: Washburn Island one vertical to 10 or 12 horizontal ($1/10$ to $1/12$); Menauhant, $1/3$; Davisville $1/44$ east portion, $1/9$ west portion; Acapesket $1/16$; Mara Vista $1/6$, east portion, $1/11$ west portion; Falmouth Heights, $1/6$ to $1/12$, east half, $1/20$ to $1/28$ west half; Falmouth Harbor to Falmouth Beach, $1/12$; Falmouth Beach, $1/10$ to $1/15$; Nobska Point to Falmouth Beach, $1/7$ to $1/10$, east portion, $1/22$ to $1/36$ west portion; Nobska Point $1/20$. Profiles generally leveled off to slopes flatter than $1/100$ at depths of 3 to 10 feet along Falmouth Beach and the shore to the east and at greater depths, up to 28 feet, west of Falmouth Beach.

e. Volumetric Accretion and Erosion. - Volumetric changes along the Falmouth Heights shore were estimated from shoreline surveys run by the town of Falmouth during October 1947, June and December 1957 and November 1958 and from a survey run for this study during July 1961. Volumes were estimated based on the assumption that beach slopes in all periods were similar to those determined from the 1961 survey of beach profiles. Accretion is attributed to hydraulic fill placed on the beach during 1957. Fill placement was completed during early May 1957. Fill was placed directly on the beach between the existing groins at Stations 198+50 and 216+50 and subsequently drifted eastward. Volumetric changes estimated between October 1947 and June 1957 are believed to have occurred principally during the first half

of 1957 as a result of placement and drifting of fill. Total changes and rates of change per linear foot of shore per year are given below from west to east for the five compartments of shore formed by existing groins.

Volumetric Changes - Falmouth Heights

Location	Volume	
	Cubic Yards	Cubic Yards Per Linear Foot/Year
<u>Sta. 198+50 to Sta. 216+50</u>		
June 1957 to Dec. 1957	-28,060	-31.2
Dec. 1957 to Nov. 1958	-29,920	-18.1
Nov. 1958 to July 1961	-10,020	- 2.1
June 1957 to July 1961	-68,000	- 9.2
<u>Sta. 216+50 to 220+0</u>		
Oct. 1947 to June 1957	+17,700	-
June 1957 to July 1961	Minor	0.0
Oct. 1947 to July 1961	+17,700	-
<u>Sta. 220+0 to 224+0</u>		
Oct. 1947 to Nov. 1958	+17,700	-
Nov. 1958 to July 1961	+ 2,940	+ 2.8
Oct. 1947 to July 1961	+20,640	-
<u>Sta. 224+0 to 227+80</u>		
Oct. 1947 to Nov. 1958	+ 5,900	-
Nov. 1958 to July 1961	+ 6,000	+ 5.9
Oct. 1947 to July 1961	+11,900	-
<u>Sta. 227+80 to 233+40</u>		
Oct. 1947 to Nov. 1958	+ 2,600	-
Nov. 1958 to July 1961	+16,100	+10.8
Oct. 1947 to July 1961	+18,700	-

The westerly compartments of shore filled or nearly filled by drifting at an earlier date than those to the east. The rate of filling increased to the eastward for the later period after November 1958 evidently due to the availability of impounding capacity and the passage of sufficient time for drifting sand to fill compartments to the west and reach those to the east.

PART III - ANALYSIS OF PROBLEM

14. Shore Processes Pertinent to the Problem. - The principal past sources of beach materials have been the eroding headlands within the area. Eroded materials have moved generally eastward forming baymouth bars across the pond entrances. Protection of the eroding bluffs has practically eliminated the supply of beach-building materials therefrom with resultant recession of the beaches. There is no apparent predominant direction of littoral drift along the central and western part of Falmouth Beach and the shore to the west to Nobska Point. East of Falmouth Beach to Waquoit Bay, the greater accumulation of beach material at the west sides of jetties and groins is visible evidence of predominant eastward movement. Occasional accumulations at the east sides of groins indicate that the direction of movement of littoral drift varies. The rate of loss of beach material generally exceeds the rate of supply. Due to the absence of natural sources of supply and the existence of numerous groins, the quantity of littoral drift is small. Volumetric accretion at the Waquoit Bay west jetty estimated from comparative shoreline changes from 1938 to 1961 was about 4,000 cubic yards per year. Eastward movement of littoral drift along the study area was therefore, at least of that magnitude. A larger rate of loss occurred at Falmouth Heights for a short period where comparative surveys show a loss of 28,000 cubic yards of fill from the area of placement during six months in 1957. Movement of material is largely along shore. Material also moves landward over the low barrier beaches and is probably also lost offshore. The greatest losses occur as a result of short period waves during storms. Some recovery of beach losses probably occurs as a result of swells during calmer periods. The loss of protective beaches is gradually exposing developed areas to more severe wave attack and damages.

15. Methods of Correcting Problem Conditions. - In general, the rate of supply of beach material cannot be increased except by artificially placing material directly on the beaches or in stockpiles to be distributed by wave action. Probing indicates that suitable material is available offshore or in the ponds within a practicable distance for hydraulic dredging and placement on the beaches. Widening the beaches in this manner is an effective method for restoring past losses, improving beaches for recreational use and providing protection for developed areas against wave attack. The inadequacy of the supply of material feeding the beaches and the existence of jetties at most inlets necessitate compartmentation of the shore and consideration of separate plans for shore segments. Although protection of eroding bluffs has reduced sand supply to beaches, compartmentation of the shore by jetties and groins has reduced losses from beaches and use of past rates of erosion in determining future nourishment requirements of restored or protected beaches is probably valid.

Numerous groins and jetties constructed along the shore have proven to be effective in reducing losses of beach material. Loss of land and damages to developed areas have been prevented, except during the most severe storms and hurricanes, by armoring the shore with sea walls, revetments and bulkheads in these areas where the supply of material has been inadequate to maintain a protective beach. Such structures have reduced the supply of material available for beaches by protecting former sources of supply. Landward movement of material over low beach areas can be prevented or reduced by raising shore roads or constructing seawalls or other barriers. Other methods of protection, such as offshore breakwaters, are not considered applicable.

16. Design Criteria. - Proposed protective measures are designed to provide protection for ordinary conditions of comparatively frequent occurrence (about once a year). They are not intended to provide complete protection in the event of hurricanes or great storms of infrequent occurrence, although even under these conditions some protection will be afforded.

a. Design Tide. - The design tide is the highest tide which occurs on an average about once a year. The elevation of the design tide is 3.0 feet above the plane of mean high water.

b. Design Wave. - The height of the design wave was determined from the relationship $d/H=1.28$ where d is the depth of breaking and H is the height of wave at breaking using the depth at or a short distance seaward of the proposed structure at time of design tide as the depth of breaking.

c. Sizes and Slopes of Armor Stones in Structures. Sizes and slopes of armor stones for groins, jetties and stone revetments are computed using the United States Army Waterways Experiment Station Formula as described in Technical Report No. 4 of the Beach Erosion Board entitled "Shore Protection Planning and Design."

d. Sand Fills. - The berm elevation of proposed beach fills is based on those at existing beaches in the study area. The minimum width of fill above mean high water is based on widths found to afford protection in the area. Estimated volumes of fill are based on slopes similar to existing slopes but fill can be placed initially to a steeper slope and permitted to take a more natural slope under wave action. Based on these criteria the beach width between the seawall and the high water shoreline is 125 feet, the berm elevation is 6.5 feet above mean low water and the fill slopes vary from 1 on 10 to 1 on 30 in accordance with existing slopes. Suitable sand for beach fills would have size and gradation characteristics similar to those of existing

beach materials. For the purpose of detailed design of the beach-fill, the investigation of materials on the beach and in proposed borrow areas should be supplemented when plans and specifications are being prepared.

e. Groins and Jetties. - The horizontal shore section should ordinarily have a top elevation not lower than the general height of existing or anticipated berms of beaches and a length not less than the berm width of the anticipated beach. This minimum top elevation has been determined to be not less than 6.5 feet above mean low water and the elevation is higher for terminal groins or jetties intended to completely block passage of littoral drift or to reduce it considerably. The intermediate sloped section should not be steeper than the slope of the existing bottom. The top elevation of the outer section should not be lower than 1 foot above mean low water for groins and not lower than 5 feet above mean low water for jetties. For stone construction, the minimum height of structures should be 5 feet. This height is increased wherever necessary to permit use of armor stones that will not be displaced by wave action. The determination of armor stone sizes is described in the preceding Subparagraph c. Blankets of spalls or crushed stone are used under stone groins or jetties to minimize settlement due to scour. The ends of structures extend seaward at least to the toes of proposed fills.

PART IV - PLANS OF PROTECTION

17. General. - Plans of protection have been considered for all known beach erosion control problems throughout the study area. Detailed plans have been developed for all specific problem areas where there is a present need for protection or improvement and typical plans or methods of protection have been indicated for use in areas where it appeared that a need for protection might develop. Descriptions, problems and plans of protection for shore areas, generally divided in accordance with physical character of shore features or the limits of public ownership, are contained in the following paragraphs. The locations of these shore areas are shown on Plate No. 9.

18. Nobska Point. - Nobska Point is located at the west limit of the study area. The shore has a length of 2,200 feet including 1,250 feet around the tip of the point, owned by the town and 950 feet extending eastward from the tip, privately owned. Development, all landward of the road bordering the shore, consists of a United States Coast Guard Station behind the town property and residences behind the private shore. The outer end of Nobska Point is a glacial till headland with a steep seaward slope protected by a stone mound and riprap revetment. The sandy shore and road to the east are protected by riprap revetment and the remains of stone groins.

Construction of the stone mound and revetment around 1,100 feet of the tip of the point during 1959 provided needed protection for the former eroding bluff and the shore road behind it. Except for maintenance of small areas where a few stones were displaced, apparently the result of loss of the underlying sand and gravel, no additional work is needed around the tip of the point. The elevation of the road, which closely borders the shore, drops to the east and it is subject to overtopping during high storm tides. This does not create a particularly serious problem since the residential development is located on higher ground well behind the shore. Protection, if desired, can be provided by reconstructing the road at a higher elevation and placement of riprap revetment along the face of the road embankment. In general, maintenance of the existing stone mound and riprap revetment should provide suitable protection for this area.

19. Between Nobska Point and Falmouth Beach. - The shore extending 5,900 feet northeastward from Nobska Point to Falmouth Beach is privately owned. Development is residential with residences widely spaced and generally located on high ground well behind the beach. The easterly 1,400 feet of shore is closely paralleled by a railroad line and residences in this area are located even farther landward. The shore is protected by a series of stone groins. Residences and glacial till bluffs behind the beach are protected by a discontinuous system of protective works consisting of low stone walls, a timber bulkhead, dumped or mortared stone revetment and stone mounds. The shore has generally receded over the period of record, since 1845, at a rate not exceeding one foot per year. In recent years, since 1941, there has been accretion in the immediate vicinity of some of the groins. The beach width above high water in front of bluffs and protective structures varies from about 30 to 125 feet. The beach is composed of medium and coarse sand and gravel with the composition coarser to the east. Existing protective works are generally suitable for protection of the beach and residential development. Some erosion occurs to the bluffs near the shore which are still unprotected. Protection can be provided by construction of stone mounds or stone revetment along the toes of bluffs as has been done at adjacent areas. Details of a typical protective stone mound are shown on Plate 11. It consists essentially of an outer layer of armor stone large enough to withstand displacement by wave attack and an underlying filter layer designed to prevent washing out of the glacial till. The size of armor stone at specific locations will depend on the size of waves which can reach the structure when the tide is at the design level and the sizes of stones in the filter layer are based on the armor stone sizes. Due to the lack of a source of supply of material

to nourish the beach by natural shore processes, it is possible that the existing sandy beach may be gradually eroded despite the construction of groins and other protective structures. In the event it becomes necessary to do so, the sandy beach can be restored, maintained or improved by the direct placement of sand fill along the shore or in stockpiles to be distributed by wave action. The choice between direct placement along the shore or in stockpiles should be based on a comparison of the costs involved. Use of stockpiles will generally be more economical only where a long reach of shore is involved. The stockpile could be placed west of the area to be improved to permit nourishment of the shore by eastward drifting. Under present conditions, there is no apparent immediate need for shore nourishment.

20. Falmouth Beach (West End). - The westerly 1,400 feet of Falmouth Beach is owned by the town of Falmouth. The public shore consists of a strip of beach on the seaward side of the railroad line with a width above mean high water of about 50 feet. The beach is largely covered with gravel with increasing amounts of sand at its surface to the east. The beach is undeveloped and directly accessible only to pedestrians across the railroad tracks from Oyster Pond Road. Dumped riprap imbedded in the beach provides some protection for the railroad tracks. The shoreline has receded at an average rate of about one-half foot per year during the period of record from 1845 to 1961. In its present undeveloped state, this erosion and shore recession does not constitute a serious problem. In the event the area is developed in the future, buildings or other structures should be located far enough landward and constructed at a high enough elevation so as to prevent or reduce damages during their intended life from continued erosion or from wave attack during storms accompanied by extreme high tides when the beach would be overtopped. Erosion of the shore can be reduced by the construction of groins as has been done along the adjacent shore to the east. Gradual loss of beach material, even if groins are constructed, may require artificial nourishment of the beach. The sand beach can be maintained or enlarged by placement of sand fill either directly on the beach or in stockpiles to be distributed by wave action. The stockpiles could be located west of the area to be improved to permit nourishment of the shore by eastward drifting. Widening of the shore by fill placement will generally require the extension of drains which cross the beach. Under present conditions of use and development, there is no apparent immediate need for either groins or shore nourishment.

21. Falmouth Beach (Central Portion). - The central portion of Falmouth Beach with a length of about 4,850 feet fronting Oyster and Salt Ponds is privately owned except for 50 feet at the jettied drainage outlet at Salt Pond which belongs to the town of Falmouth. A railroad line is located on and closely parallels the

shore for about 800 feet at its west end and a town road, Surf Drive, closely parallels the rest of the shore. There are approximately 20 summer cottages on the beach seaward of Surf Drive, most of them concentrated in front of Salt Pond. The beach is composed of medium and coarse sand and scattered layers of fine gravel deposits, the latter diminishing and ceasing at the east end of the area. The beach width above high water varies from about 70 to 140 feet in front of the railroad tracks, 20 to 100 feet fronting Surf Drive opposite Oyster Pond and the west end of Salt Pond and 60 to 160 feet fronting Surf Drive along the cottage development at the east end of the area. During the period of record from 1845 to 1961, parts of the shore receded at an average rate generally ~~less than one foot per year~~. From 1941 to 1961 the shoreline position remained comparatively unchanged or it moved a small distance seaward. Some of the area is protected by a system of stone groins and jetties which have been effective in reducing or preventing shore recession. Portions of Surf Drive are fronted by dumped riprap or a low wall. Due to its narrowness and low elevation, the beach is subject to overtopping during storms and hurricanes accompanied by extreme high tides. Landward movement of large quantities of beach sand occurs as a result of wind and wave action. This material covers Surf Drive and makes it impassable. Cottages on the beach sustain damages from direct wave attack and flooding during storms or hurricanes. Under these conditions some of the cottages have been floated off their foundations to the landward side of Salt Pond from whence they have been recovered and replaced on the beach. Erosion of the beach can be effectively prevented or reduced by maintenance of existing groins. Complete protection of the development on the beach could be effected by construction of a fronting seawall, dike or some other form of high barrier. A large measure of protection could be provided by widening the existing beach, where needed, by direct placement of sand fill on the beach or in stockpiles to be distributed by wave action. Lengthening of existing groins to reduce fill losses from a widened beach would probably be necessary. Due to the type of use and the limited development involved, construction of a high fronting barrier or placement of a wider sand beach does not appear to be warranted. Raising the elevation of Surf Drive or constructing a low seawall or barrier to reduce landward movement of sand would be a suitable form of partial protection for the road and the development behind it. The beach itself is more suitable for use as a bathing area than for cottage development. It is, therefore, advisable to consider restricting it to such use.

22. Falmouth Beach (East End). - The easterly 2,350 feet of Falmouth Beach is owned by the town of Falmouth and it is used as a public bathing beach. There is a parking lot at the west end and a bathhouse and a parking lot at the east end. The shore is

bordered by a town road with residences along its landward side. The beach width between the high water line and the shore road increases eastward from about 70 to 160 feet. The beach composition is finer to the east. It consists of coarse and medium sand with the backshore partially covered with low-grassed sand dunes. Two stone jetties across the beach train the flow of a culvert which drains Siders Pond. There are two shore-connected curved stone breakwaters at the east end of this shore which act as a littoral barrier impounding a sand beach to the west. The parking lot at the bathhouse is protected by stone revetment and a bulkhead. The shoreline in 1961 was generally at or seaward of its position in 1845 indicating that the beach is stable or benefitting from accretion. The beach is in good condition. Some landward movement of sand over the shore road occurs as a result of wind or wave action but the beach is generally wide enough to protect the development landward of it from storm damages. It is possible that due to lack of a natural source of supply of beach building materials that erosion and recession of the shore may occur at some future time. In this event, the sand beach could be maintained by placement of sand fill either directly on the beach or in stockpiles located to the west to be distributed by eastward drifting. There is no present apparent need for such nourishment. Drifting of sand and formation of a sand bar between the jetties at the Siders Pond culvert periodically stops the drainage causing a problem of local concern. Correction of this problem could be effected by either seaward extension of the jetties to prevent drifting of sand around their ends or by seaward extension of the drain. Extension of the jetties or drain out to a depth of six feet would probably be adequate. The extension of the jetties by interfering with the natural drifting of sand might have an adverse effect on the adjacent shore. The drain extension would have the advantage of permitting free movement of sand along the beach over the culvert and elimination of the need for jetties.

23. Between Falmouth Beach and Falmouth Inner Harbor. - The shore extending eastward about 2,400 feet from Falmouth Beach to the west jetty at the Falmouth Inner Harbor entrance is privately owned. Development consists of residences generally located well behind the shoreline. The development and the shore are protected by a variety of structures consisting of stone mounds, riprap revetment, stone, timber and concrete groins and stone and concrete walls. Along the west end of the area a stone mound is located at the shoreline with no fronting beach. In the central portion of the area there is a sand beach about 40 feet wide fronting protective structures and this beach width increases eastward to about 150 feet at the harbor jetty. The beach is composed of coarse to medium sand, with gradation finer to the east. During periods prior to 1941, the shore, except adjacent to the west jetty, has receded up to about 1 foot per year. The west jetty, constructed in 1909 resulted

in accretion adjacent to it of about 150 feet to 1941 and another 100 feet up to 1961. No other significant changes occurred within the area from 1941 to 1961 indicating that existing structures have stabilized the shore. If additional protection is desired, it can be effected by direct placement of sand fill along the shore to provide a wider sand beach. The use of a stockpile west of the area would probably not be effective due to the existence of the breakwaters at Falmouth Beach which act as a littoral barrier. Eastward drifting of sand placed along the shore could result in narrowing of the west end of the fill and filling of the west jetty at the Falmouth Inner Harbor entrance to the limit of its impounding capacity with consequent movement of sand around the jetty into the harbor entrance. Prevention of harbor shoaling under these conditions would require extension of the jetty. Eastward drifting could be reduced by construction of groins west of the jetty to hold a beach of the desired width. This might eliminate the need for extension of the jetty. Under conditions of present use, existing structures, if maintained, should provide adequate protection for the development although during exceptional storms or hurricanes overtopping and flooding could occur.

24. Falmouth Heights. - The shore of Falmouth Heights with a length of 5,450 feet borders shore roads between the Falmouth Inner Harbor east jetty and the culvert at the Little Pond inlet. The westerly 150 feet adjacent to the stone jetty is a town beach provided with a public parking area. The ~~private~~ bathing beach for about 1,000 feet to the east is occupied by a motel at its west end. The shore east of the motel is accessible from the shore road and it is used by the public for bathing. Mortared stone revetment protects the motel and dumped riprap protects the shore road. The town of Falmouth owns the next 3,450 feet of shore to the east except for 230 feet at a theatre, the Casino, which is private. This public shore extends around the base of the steeply sloping face of a bluff for about 1,800 feet and thence along a town bathing beach. The bluff is protected by a low concrete wall around its base with riprap along its toe and stone revetment on the slope above the wall along its eastern portion. There is a low stone groin at the west end of the bluff and another at the east end. The Casino is protected by dumped riprap. There are three stone groins along the public bathing beach and a concrete seawall fronting a park area behind it. The shore extending 850 feet east of the public bathing beach is private except for the culvert and inclosing stone jetties at Little Pond which belong to the town. The west half of this private beach is occupied by residences and the east half is an undeveloped barrier bar. The residences are fronted by concrete walls and three stone groins and the road along the barrier bar is fronted by a concrete wall or dumped riprap. Development landward of the entire Falmouth Heights shorefront consists of residences, summer hotels and inns.

25. The beach is composed of sand varying from fine to coarse and small amounts of gravel. The width above high water varies considerably. It is 70 to 80 feet along the west end with little or no beach around the base of the adjoining bluff, 90 to 165 feet along the public bathing beach and 40 to 90 feet along the private shore to the east. During different periods between 1845 and 1941, comparative shoreline locations indicate that the shore has receded about one-half to one and one-half feet per year. Due to placement in connection with a Federal navigation improvement of approximately 120,000 cubic yards of sand fill dredged from Falmouth Inner Harbor along the shore of the Falmouth Heights bluffs during 1957 and subsequent drifting, the 1961 locations of the high water line along all of the area were generally seaward of their 1941 positions. The fill was eroded rapidly from the area of placement and nourished adjacent shores. This created the present wide sandy public bathing beach east of the bluffs and probably also resulted in widening of the shore west of the bluffs. The beneficial effect which was obtained by placement of dredged fill along the shore of the bluff between Vernon and Walden Avenues during 1957 indicates that stockpiling sand at this location is a suitable method for nourishing the adjacent beaches. Therefore, it is desirable that sand fill from future harbor maintenance, estimated to average 7,500 cubic yards per year, be placed on the beach east of the entrance. The rapid erosion of fill from the area of placement indicates that sand fill placed to provide a protective beach for the bluffs would have to be replaced frequently.

26. Due to erosion and narrowing of the beach, the concrete seawall fronting the bluff is subject to damages from wave attack and undermining. Erosion of parts of the unprotected face of the bluff above the wall occurs but this erosion is due more to surface runoff than to overtopping. Protection against undermining and wave attack can be provided by placement of additional riprap along the toe of the wall. Erosion of the bluff above the wall can be prevented by interception or control of surface runoff and by extending the existing stone slope protection. A typical section showing this type of protection is shown on Plate 11.

27. Additional recreational beach area can be provided if needed for public recreational use along the private shore between Falmouth Inner Harbor and the bluffs to the east by placement of sand fill to widen the beach and enlargement of the existing groin at the east limit of the fill to reduce losses by eastward drifting. This widening would provide protection for the backshore in addition to recreational area. Enlargement of the groin, however, would decrease the supply of material to the public beach east of the bluffs until the groin was filled to the limit of its impounding capacity. Some losses of beach material occur by westward drifting around the Falmouth Inner Harbor east jetty resulting in shoaling of the harbor entrance. These losses and the harbor shoaling can

be reduced by seaward extension of the jetty. A plan of improvement and protection consisting of beach widening by fill placement, enlargement of the existing groin at the east limit of the fill and extension of the east jetty at the harbor entrance is shown on Plate 11.

28. Maintenance of the existing groins and replacement of sand fill losses, when needed, is a practicable method of maintaining the public bathing beach. The private shore at the east end of this area is being nourished by eastward drifting sand from the adjacent shore. Residences here are now adequately protected. Some overtopping of the low road fronting Little Pond occurs. Construction of a barrier to provide complete protection does not appear to be warranted. Raising the shore road or constructing a low wall along its landward side would provide partial protection which appears to be all that is warranted under present conditions of use.

29. Mara Vista. - The shore of Mara Vista extends approximately 2,400 feet from the Little Pond drainage culvert to Great Pond Inlet. At its ends, it consists of low baymouth bars fronting Little and Great Ponds. The shore is privately owned. Development consists of cottages and residences concentrated between the ponds on both the landward and seaward sides of a low road which closely borders the shore. The only buildings on the barrier bars are located on the landward side of the road fronting the west end of Great Pond. The beach between the high water line and the shore road varies in width from 50 to 90 feet fronting Little Pond and from 80 to 90 feet fronting Great Pond, increasing to 200 feet at the jetty at Great Pond Inlet. There is no beach fronting the development between the ponds which is protected by concrete walls, some with riprap revetment at their toes, and by concrete and stone groins. West of the development protective structures consist of the stone jetties at the culvert, a stone groin and the remains of concrete walls. To the east of the shore development, shore protection consists of rows of wood piles, dumped riprap, timber bulkheads and groins, low concrete walls and stone groins. The remains of protective works and abandoned concrete foundations along the barrier bars are mute evidence of former development. The barrier bars are composed mostly of sand varying from fine to coarse and some gravel. There are grassed sand dunes in the backshore east of the shore cottages. Some of the area landward of the shore road in the Great Pond section is the result of filling. Shoreline changes from 1845 to 1941 generally consisted of recession averaging about 1 to 1-1/2 feet per year. Since 1941, shoreline changes have consisted of a small amount of accretion at the west end and recession at the east end of the area with little change along most of the shore. The entire area is low and subject to

overtopping and wave attack during storms. Landward movement of beach material over the barrier bars can cover the shore road and damage it and any development on the bars. Due to the lack of a fronting beach, waves can break on and overtop protective structures fronting the shore cottages. The small amount of change in the shoreline position since 1941 indicates that the existing groins and walls have been successful in controlling recession of the shore. Complete protection of the area would require the construction of a high-fronting seawall or other barrier to prevent damaging wave attack, overtopping and landward movement of beach material. Such construction is not warranted by the limited amount of development which would benefit. In their present condition, the barrier bars are unsuitable for residential development due to their low elevation and consequent vulnerability to storm damages. Consideration was given to providing partial protection for this entire area by placement of sand fill to create a wider protective beach and construction of groins to retain or reduce losses of the fill. The beach could also be widened and nourished by placement of sand in a stockpile at the west end of the area and allowed to be distributed eastward along the shore by wave action. Extension of the west jetty at the Great Pond Inlet would be required to impound drifting sand and protect the inlet from shoaling. Use of the stockpile method of nourishment would result in higher rates of loss of the fill and require more frequent replenishment of the fill than if groins are used. Due to the steep foreshore slope and the proximity of comparatively deep water in the offshore area, the cost of the types of protection involving beach widening would probably be higher than warranted by prospective benefits. Partial protection for the shore road against overtopping and drifting sand can be provided by construction of a low wall along the seaward edge of the road where existing structures are not adequate for this purpose as shown on Plate 11. Maintenance of existing seawalls, groins and other structures should provide adequate protection for the shore residential development and for the sandy beaches under ordinary conditions but damages will occur during exceptionally severe storms.

30. Acapesket. - The Acapesket shore located between the jetties at the Great and Green Pond Inlets has a length of approximately 2,750 feet. Ownership is entirely private. Development consists of cottages on the landward side of the shore road along the westerly third of the area and on both sides in the central portion. The barrier bar fronting Green Pond along the easterly third of the shore is undeveloped. The beach is composed of medium and coarse sand and some gravel. Its width above high water varies irregularly. There is little or no beach along the west end where the shore road, closely bordering the shore, is protected by rip-rap, and a curved face precast concrete block wall and stone groins.

In the central portion, the sand beach varies from 0 to 80 feet, the greater width at the west sides of stone groins. In this area, cottages on the seaward side of the shore road are protected by stone groins, a stone mound, riprap and timber bulkheads. The barrier bar fronting Green Pond has a width of 200 to 300 feet and it is partially covered with grassed sand dunes. Shoreline changes along the entire Acapesket shore have been large over the period of record. Between 1845 and 1941, the shoreline receded at an average rate of 2 to 4 feet per year, the larger recession along the east half. From 1941 to 1961 the barrier bar fronting Green Pond and a segment of shore adjacent to the Great Pond Inlet receded up to about 200 feet more while changes along the rest of the area were comparatively small. Due to the narrowness of the beach fronting the shore road and the shore cottage development, the area is subject to damages from erosion, wave attack and overtopping. Some settlement of the precast concrete block wall which protects the shore road has occurred and the lawns fronting cottages are subject to erosion resulting from overtopping of the beach and existing protective structures. A large measure of protection is already afforded by existing protective works. Complete protection could be provided by construction of higher walls or barriers and armoring the shore with more riprap revetment. Due to the limited development which would benefit, provision of complete protection does not appear to be warranted. Partial protection can be provided by placement of a wider protective sand beach. The high rate of past shoreline recession indicates that beach fill material would be lost at a fairly rapid rate and that construction of groins to reduce fill losses would be necessary. A plan of protection involving placement of a wider protective sand beach and enlargement of existing groins to reduce fill losses has been developed in the event that prospective use or benefits should warrant such construction. The plan is shown on Plate 11. Maintenance of the existing system of protective works should generally provide the type of protection needed under present conditions of use.

31. Davisville. - The Davisville shore is located between the Green and Bournes Pond Inlets. It has a length of approximately 2,950 feet. Except for two town street ends, the area is privately owned. Development consists of summer residences which closely border the shore. The beach is composed mostly of medium sand and some coarse sand and gravel. At the west end, the area is an undeveloped barrier bar about 200 feet wide fronting Green Pond. The beach width above high water to the east along the residential development varies irregularly in front of lawns and protective structures from 0 up to 90 feet and it widens to 125 feet in front of a grass-covered dune and stone mound at the east end. The development is fronted by a continuous system of protective structures consisting of stone mounds, timber bulkheads and piles, riprap revetment and stone, timber and concrete groins.

During the period of record, from 1845 to 1941, the shoreline receded an average of 1 to 4 feet per year, with the largest shore loss at the west end. Since 1941, recession generally less than 25 feet, occurred along the west half and a seaward shoreline movement of 25 to 50 feet occurred along the east half of the shore. The reduction in the rate of shore recession and the accretion which has occurred since 1941 indicates that the existing protective structures have been successful in controlling erosion. Some erosion of the low bluff and lawns behind the beach occurs where the bluff has not been protected. Armoring the bluff by construction of stone mounds or placement of riprap revetment has provided effective protection in this area. The groins have been effective in reducing erosion. In the absence of natural sources of supply of beach building materials, these methods would not provide an adequate width of fronting protective sand beach. Unless such a supply is furnished, losses of the existing sand beach will gradually expose the area to more severe wave attack and require the construction of increasingly stronger protective works. A protective sand beach can be provided by direct placement of sand fill. Construction of groins would be necessary to reduce rapid losses of the fill. A plan of protection and improvement involving beach widening by fill placement, construction of a jetty at the Bournes Pond Inlet and construction of two new groins has been developed for possible future use and it is shown on Plate 12. Beach widening can also be effected by placing sand fill at the west end of the area and allowing it to nourish the shore by eastward drifting. Construction of a jetty would be required at the east end of the area to impound drifting sand and protect Bournes Pond Inlet from shoaling. This method of nourishment would be accompanied by a higher rate of loss of fill than the plan involving groin construction. Under present conditions of use and exposure, maintenance of existing or construction of additional seawalls, stone mounds, revetments or groins should provide adequate protection.

32. Menauhant. - The Menauhant shore, located between the Bournes Pond and Eel Pond Inlets consists of 1,850 feet of town-owned public bathing beach and 1,500 feet of privately-owned shore. The public beach is on a low sandy barrier bar fronting Bournes Pond. The road on the bar is protected by dumped riprap where it closely borders the shore. The fronting sandy beach varies irregularly in width from about 130 to 20 feet and it is protected by a series of 4 stone groins. There are no buildings on the bar. The private shore to the east is protected by 3 stone groins and a stone jetty at the Eel Pond Inlet, the two westerly structures fronting a residential development, the other two on an undeveloped sandy barrier bar at Eel Pond. There is a stone mound fronting the residential development with little or no width of sandy beach in front of the mound. The sandy barrier bar at Eel Pond is about 200

feet wide. Except for one residence, all buildings are located on the landward side of the shore road. Between 1845 and 1942, the entire shore receded at an average rate of 1 to 3 feet per year. From 1942 to 1961, along the west half of the Menauhant shore, there was a seaward shoreline movement of 25 to 50 feet and during the same period the shore fronting Eel Pond receded a similar amount. The beach and barrier bars are low in elevation and subject to overtopping during storms accompanied by high tides. Damages occur along the residential development and the public shore area to the west where beach material moves landward over the shore road and onto lawns. The road is subject to damages from wave attack where the beach width is inadequate to provide protection. Some erosion of lawn areas also occurs. Consideration has been given by local interests to construction of a new bridge over Bournes Pond Inlet and relocation of the Menauhant shore road at a higher elevation along the landward side of the barrier bar. This would make it possible to provide complete protection for the road without interfering with or impairing the recreational use of the beach. Complete protection can be provided for the entire shore area by construction of high seawalls or other barriers seaward of the shore road and buildings but this is not warranted by the limited development which would benefit. Improvement and partial protection of the public shore and road and the private development can be provided by placement of sand fill to create a wider sand beach and construction of a low seawall along the seaward edge of the road. The history of recession of the shore indicates that groins would be required to reduce the rapid loss of the fill. A plan of protection and improvement involving beach widening along the private residential area and the narrow portion of the adjacent public bathing beach, the construction of a low seawall and the enlargement of three existing groins to reduce losses of the beach material has been developed for use in the event that future development or recreational use of the shore should warrant it. The plan is shown on Plate 12. The beach could also be widened and nourished by placing a stockpile of sand at the west end of the area and allowing the sand to drift eastward. Losses of fill would be higher using this method than with the fill plan involving groin construction. Maintenance of existing protective structures appears to be all that is warranted for present or prospective use of the barrier bar fronting Eel Pond.

33. Washburn Island. - The seaward end of Washburn Island is a sandy barrier bar extending about 5,800 feet from the entrance to Eel Pond to the entrance to Waquoit Bay. It is privately owned and completely undeveloped. There is a limited amount of development on that portion of the island extending northward from the beach. The bar increases in width from west to east from about 200 to about 1,000 feet and thence

decreases to about 400 feet at the Waquoit Bay Inlet. The shoreline from Menauhant to Washburn Island was continuous during 1845 and 1891. An opening into Eel Pond during the period 1938-1941 separated these two beaches, as at present, but a shoreline map shows a continuous shoreline here during 1942. The entire shoreline of Washburn Island receded at a rate of about 2 feet per year between 1845 and 1891. From 1891 to 1942 the shoreline receded about 200 feet at its west end and moved seaward about 300 feet at the Waquoit Bay entrance with the amount of change decreasing from the ends to an area of no change near the center. This pattern of shoreline movement continued from 1942 to 1961 resulting in a recession of about 500 feet more at the Eel Pond entrance and accretion of another 100 feet at the Waquoit Bay entrance. The accretion at the east end of the area is attributed to impounding of drifting beach material by construction of a jetty at the west side of the Waquoit Bay Inlet in 1937. The retreat of the west end of the barrier bar has left three stone groins which were built here, stranded offshore. The west end of the area is considered to be unsuitable for development at the present time due to the rapidity and magnitude of changes which have occurred. In the event that the wider, more stable east end of the island is developed, a safe escape road which would not be blocked or made unusable during storms or hurricanes should be provided. If future development requires it, this entire beach can be maintained by placing a stockpile of sand at its west end and allowing it to be moved eastward by wave action to nourish the shore. Beach material would be impounded by the west jetty at the Waquoit Bay entrance. Stabilization of the west end of the beach could be effected by construction of a jetty at the Eel Pond entrance west of the stockpile and a bulkhead or other barrier to landward movement from the jetty eastward behind the stockpile or behind the beach. Due to the lack of any development in the immediate area, there is no present need for the construction of protective works. The need for protective works for any future development can be eliminated or greatly reduced by proper planning so as to locate buildings or other structures a safe distance landward of the shoreline.

PART V - ECONOMIC ANALYSIS

34. First Costs. - Detailed estimates of costs are included in Appendix I. First costs have been estimated for all projects for which detailed plans have been developed. Estimates are based on price levels prevailing during July 1962. Detailed plans have been developed for the locations tabulated below:

Location	Shore Ownership	Paragraph Reference	Plate No.
Shore between Nobska Point and Falmouth Beach	Private	19	11
Falmouth Heights (West End)	Public & Private	20	11
Falmouth Heights (Central Portion)	Public	21	11
Mara Vista	Private	29	11
Acapesket	Private	30	11
Davisville	Public & Private	31	12
Menauhant	Public & Private	32	12

The estimated total costs or costs per linear foot for construction of the projects developed in detail are tabulated below:

Project	Work Items	Cost Per Linear Foot
Between Nobska Point and Falmouth Beach	Stone Mound and Slope Protection	\$ 81.00
		<u>Total Cost</u>
Falmouth Heights (West End)	Groin and Jetty Enlargement and Beach Fill	\$ 89,000
Falmouth Heights (Central Portion)	Stone Revetment and Slope Protection	48,000
Mara Vista	Concrete Wall	28,000
Acapesket	Enlargement of 4 Groins and Beach Fill	278,000
Davisville	Construction of Jetty, 2 Groins and Beach Fill	207,000
Menauhant	Enlargement of 3 Groins, Beach Fill and Concrete Wall	495,000

35. Annual Charges. - All estimated annual charges have been computed as non-Federal annual charges. An interest rate of 3.5% has been used. A useful life of 50 years has been assumed in determining amortization charges. Maintenance estimates for beach fills are generally based on the maximum rates of loss determined from past shore recession. A shore recession of 2 feet per year was assumed for the fill area at Falmouth Heights. It has been assumed that the proposed groin and jetty construction will reduce the rate of loss of beach fill by 50 percent. Estimated annual costs, computed in detail in Appendix I, are as follows:

Location	Interest	Amortization	Maintenance	Total Per Linear Foot
Between Nobska Point and Falmouth Beach	\$ 2.80	0.60	0.60	\$ 4.00
				Total
Falmouth Heights (West End)	3,100	700	2,100	5,900
Falmouth Heights (Central Portion)	1,700	370	510	2,580
Mara Vista	1,000	200	300	1,500
Acapesket	9,700	2,100	3,800	15,600
Davisville	7,250	1,580	2,770	11,600
Menauhant	6,800	1,400	3,300	11,500

36. Benefits. - Benefits have not been evaluated since economic justification was apparently lacking or the benefits are not of a type to make the projects eligible for Federal aid under existing Federal policy. The protection between Nobska Point and Falmouth Beach is for private property and the benefits to be derived are wholly private. The projects for the west end of Falmouth Heights and for Menauhant are for shores which are partly public and partly private. The projects would enlarge the beaches for recreational use and would result in minor public benefits from protection of the shore roads. Lengthening the Falmouth Inner Harbor East Jetty would reduce harbor shoaling. The beach areas involved are adequate for present recreational use. No recreational benefits can be evaluated for present or prospective use based on available information. The central portion of Falmouth Heights is publicly owned. Public benefits from prevention of erosion of the bluff would have a small monetary value which would not be sufficient for economic

justification. The Acapesket shore is all privately owned. Benefits would be principally private, consisting of prevention of erosion and storm damages to the private residential development. Some minor public benefits would result from protection of the shore road but these benefits would have only a small monetary value. The Davisville shore is principally private and benefits would be almost entirely private, consisting of prevention of erosion and storm damages to the private residential development.

37. Apportionment of Costs. - Public Law 826, 84th Congress, established a policy of Federal aid for restoration and protection against erosion of the shores of the United States, its territories and possessions. Private shores are eligible for Federal assistance if there is a benefit such as that arising from public use or from protection of nearby public property, or if the benefits to those shores are incidental to the project. The benefits which could be evaluated for protection or improvement of public shores are insufficient for economic justification of the projects. Protection or improvement of private shores would not result in significant public benefits. All estimated costs, therefore, are apportioned as non-Federal costs.

38. Coordination With Other Agencies. - Coordination has been maintained with the cooperating agency, the Division of Waterways of the Massachusetts Department of Public Works and with officials of the town of Falmouth. They furnished information and data which were used in the conduct of the study. The plans of protection were discussed with both during the progress of the study and their comments were requested upon completion of this report. The Massachusetts Water Resources Commission was also informed concerning the report recommendations. The Barnstable County Health Department furnished information concerning bacterial tests of shore waters. The United States Coast and Geodetic Survey furnished maps, aerial photographs and data on tidal observations. The views of the Federal and State fish and wildlife agencies concerning aspects of the study pertaining to their interests were requested.

39. Comments of Local Interests and Other Agencies. - The Division of Waterways of the Massachusetts Department of Public Works reviewed the findings of the study and concurred in its conclusions. It stated that the results of the study will be extremely useful in the future for use by the town and the Commonwealth for planning projects within the areas studied. The Massachusetts Division of Fisheries and Game, based on its review of the study findings, advised that:

a. The proposed stone mounds, revetment and low walls between Nobska Point and Falmouth Beach, at Falmouth Heights

Bluffs and at Mara Vista would have no apparent adverse effect on the fish and wildlife resources of the area nor do they afford opportunity for their enhancement.

b. In the remaining proposed project areas there is opportunity for enhancement by providing additional access vantages for land-based marine sports fishermen. This could be accomplished by constructing stone groins and jetties so as to facilitate public fishing therefrom by minimizing voids and irregularities to permit persons to walk on the structures.

c. Emphasis should be placed on construction of the following structures in closest proximity to the salt pond openings where desirable species of fish concentrate as a result of tidal flow:

- The Falmouth Harbor east jetty
- The west and east groins at Acapesket
- The jetty at Davisville adjacent to the Bournes Pond opening
- The east groin at Menauhant

d. Further opportunities for enhancement consisting of habitat improvement could be realized by obtaining fill for beaches from deepening of existing channels within adjacent salt ponds. This would provide for a better exchange of tidal waters between Vineyard Sound and the salt ponds and a subsequent improvement in sport fishing conditions.

e. The removal of beach fill materials from other than existing channels in salt ponds could be detrimental to marine aquatic populations. All sport fishes are either directly or indirectly dependent upon the natural, undisturbed estuarine environment for their existence. In fact, the winter flounder, the most important species to the greatest number of marine sport fishermen, would definitely be adversely affected by the removal and/or change of this habitat.

f. If dredging for fill is undertaken in existing channels of salt ponds for beach fill, it is recommended that such not be conducted during the period from January 1 to April 1. Inasmuch as winter flounder utilize the salt ponds for spawning, dredging and resultant siltation during this period could adversely affect spawning success.

The United States Fish and Wildlife Service furnished a conservation and development report prepared in cooperation with the Massachusetts Division of Marine Fisheries and Division of Fisheries and Game. This report in its entirety is included as Appendix L. Principal comments on the proposed plans of protection were as follows:

a. The proposed works would be situated in areas of biological significance. Shellfish in the salt water ponds support a commercial and recreational shell fishery of considerable significance. Finfish resources support a highly valued sport fishery. The evaluated benefits estimated from sport fishing from groins and jetties which would be affected by the proposed projects are \$36,000 annually in their existing condition, \$94,500 with the proposed projects and \$127,500 if the proposed projects were modified by provision of parking areas and construction of structures to facilitate fishermen use.

b. Dredging offshore or from inland borrow pits to obtain beach fill and construction of stone mounds or stone revetments would not have any significant effect upon fish and wildlife resources. Dredging from the ponds behind the beaches would be damaging to the resources if fill were removed from certain areas. Dredging of the marshland along the southwestern and western shores of Green Pond would destroy habitat of special value to shorebirds. Recommended dredging areas and shellfish habitat are shown on plans of Falmouth Inner Harbor, Bournes Pond and Great Pond. Dredging in indicated areas would enhance habitat conditions for finfish and shellfish. The town should be notified 90 days in advance of dredging in Falmouth Inner Harbor or Great Pond to permit removal of shellfish and dredging should be done between October 1 and January 1 in any pond of indicated significance to shellfish or waterfowl to minimize siltation damages. Dredging should be done in such manner that the seaward end of each channel be dredged through the offshore shoals at the pond entrance to provide a continuous channel and unimpeded interchange of waters between the ponds and the sound. Marsh habitat or marshland should not be used as spoil areas, or filled to provide parking areas, if convenient parking facilities can be provided elsewhere. Parking areas should be constructed on the land side of the road.

c. Due to access possibilities and use, potential increase in sport fishery benefits would be most applicable to the proposed construction or enlargement of the following groins or jetties:

Falmouth Harbor east jetty
Groin 1200 feet east of Falmouth Harbor
Groin 1000 feet west of Green Pond
Two groins at Davisville
Bournes Pond west jetty
Three groins at Menauhant.

PART VI - CONCLUSIONS AND RECOMMENDATIONS

40. Conclusions. - The Division Engineer concludes that the following are practicable plans for protection and improvement of shore areas which merit consideration, all as shown on Plates 11-12.

a. Between Nobska Point and Falmouth Beach. - Construct stone mounds or stone revetment wherever needed for bluff protection.

b. Between Falmouth Inner Harbor and Bluffs at Falmouth Heights. - Widen 1,000 feet of beach by direct placement of sand fill, lengthen Falmouth Harbor east jetty to 250-foot length, enlarge and lengthen existing groin to 250-foot length.

c. Falmouth Heights Bluffs. - Place additional riprap revetment along the toe of approximately 1,450 feet of wall, place stone revetment on approximately 750 feet of slope above the wall and control surface runoff wherever needed.

d. Mara Vista. - Construct low walls, approximately 1,900 feet long along the seaward side of the shore road.

e. Acapesket. - Widen 1,300 feet of beach by direct placement of sand fill, enlarge and lengthen four (4) existing groins to 345 to 510-foot lengths.

f. Davisville. - Widen 1,500 feet of beach by direct placement of sand fill, construct a jetty 530 feet long and two groins 340 and 510 feet long.

g. Menauhant. - Widen 1,600 feet of beach by direct placement of sand fill, construct a low wall 1,500 feet long, enlarge and lengthen three (3) existing groins to 240 to 280-foot lengths.

41. The tip of Nobska Point is adequately protected by the existing stone mound and stone slope revetment. Maintenance of these protective works is all that is needed here.

42. Suitable protection for the low shore road east of the tip of Nobska Point can be provided by maintenance of the existing riprap revetment. Protection against overtopping, if desired, can be provided by reconstructing the road at a higher elevation and placing riprap revetment along the road embankment.

43. The shore between Nobska Point and Falmouth Inner Harbor is, in general, suitably protected against erosion and shore recession by existing protective works. Maintenance of existing structures or construction of additional similar structures is all that is needed at the present time. If it is desired or becomes necessary in the future, the existing beaches in this area can be improved, maintained or restored by placement of sand fill directly on the beaches or in stockpiles to be distributed by wave action.

44. The use of stockpiles of sand placed at the shore to be distributed by wave action is a suitable method for maintaining and

improving the sand beaches at Falmouth Heights, Washburn Island and from Nobska Point to and including Falmouth Beach. Direct placement of sand fill along the beaches is probably more suitable than the stockpile method for maintaining beaches at Acapesket, Davisville, Menauhant and the shore between Falmouth Beach and Falmouth Inner Harbor.

45. Barrier bars throughout the study area are generally unsuitable for residential development due to their low elevation and vulnerability to overtopping and damages during severe storms or hurricanes.

46. Complete protection of low shore areas by high seawalls or other barriers to prevent overtopping and consequent damages during severe storms or hurricanes is not warranted by the limited developments which would benefit.

47. Reconstruction or relocation of low shore roads at higher elevations landward of their present locations is a suitable means for protecting the roads and the developments landward of them.

48. In the event that the public shore at the west end of Falmouth Beach or the shore at Washburn Island are developed, buildings or other structures should be located at a high enough elevation or far enough landward to minimize damaging wave attack which could occur during severe storms or hurricanes.

49. Due to the adequacy of public beach areas for present recreational use, the lack of information to indicate the need for additional area for prospective use, the small value of benefits to be derived from protecting public roads and public lands or the private ownership and consequent private benefits to be derived from protecting private property, the public interest, as required by Public Law 826, 84th Congress, is insufficient to warrant Federal participation in the cost of the projects considered.

50. Additional information on recommended or alternative projects called for by Resolution 148, 85th Congress, 1st Session, adopted 28 January 1958 is contained in Appendix J to this report.

51. Recommendations. - It is recommended that no project be adopted by the United States at this time for the protection or improvement of the shores of Falmouth, Massachusetts. It is further recommended that protective measures which may be undertaken by local interests based upon their determination of

economic justification be accomplished in accordance with plans and methods considered in this report.

24 Incls
12 Appendices
12 Plates

P.C. HYZER
Colonel, Corps of Engineers
Division Engineer

APPENDIX I

ESTIMATES OF COSTS OF IMPROVEMENTS

1. General. - A useful life of 50 years has been used in determining amortization charges. An annual interest rate of 3.5 percent has been used for the annual charges which are all non-Federal. Maintenance requirements for beach fills are based on maximum rates of loss determined from past shore recession with a minimum rate of loss of one foot per year. A shore recession of two feet per year was assumed for the fill area at Falmouth Heights. It has been assumed that groins and jetties will reduce the rates of loss by 50 percent. Annual maintenance costs of jetties, groins, revetments and seawalls have been estimated as one percent of the first cost of construction.

2. Shore Between Nobska Point and Falmouth Beach. - The plan of protection consists of a stone mound and slope protection for the bluffs in this area. Costs have been developed per linear foot of improvements.

a. First Cost Per Linear Foot

Mound and slope protection, 9.3 tons stone

@ \$7.00	\$73.00 *
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Engineering and Design	<u>2.00</u>
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Subtotal	\$75.00
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Supervision and Administration	<u>6.00</u>
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Total First Cost	\$81.00
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*Includes Contingencies

b. Annual Charges Per Linear Foot

Interest - $0.035 \times \$81.00$	\$2.80
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Amortization $0.00763 \times \$81.00$	0.60
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Maintenance	<u>0.60</u>
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Total Annual Charges	\$4.00
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3. Falmouth Heights (West End). - The plan of protection and improvement consists of beach widening by direct placement of sand fill, extension of the East Jetty at Falmouth Inner Harbor, and enlargement and extension of one groin.

a. Total First Cost

Jetty extension - 1,700 tons stone @ \$12.00	\$23,400 *
Groin enlargement 1,000 tons stone @ \$12.00	13,600 *
Beach fill - 25,000 cu. yds. @ \$ 1.50	<u>43,100 *</u>
Subtotal	\$80,100
Engineering & Design	<u>2,400</u>
Subtotal	\$82,500
Supervision & Administration	<u>6,500</u>
Total First Cost	\$89,000

* Includes Contingencies

b. Total Annual Charges

Interest - $0.035 \times \$89,000$	\$ 3,100
Amortization $0.00763 \times \$89,000$	700
Maintenance	
Jetty repairs - 17 tons stone @ \$12.00	200
Groin repairs - 10 tons stone @ \$12.00	100
Beach fill - 1,200 cu. yds. @ \$ 1.50	<u>1,800</u>
Total Annual Charges	\$ 5,900

4. Falmouth Heights (Central Portion). - The plan of protection consists of placement of riprap revetment fronting an existing seawall and stone slope protection on the bluff landward of the wall.

a. Total First Cost

Revetment,	5,200 tons stone @ \$6.00	\$35,700 *
Slope protection,	1,100 tons stone @ \$6.00	<u>7,500 *</u>
	Subtotal	\$43,200
	Engineering & Design	<u>1,300</u>
	Subtotal	\$44,500
	Supervision & Administration	<u>3,500</u>
	Total First Cost	\$48,000

*Includes Contingencies

b. Total Annual Charges

Interest	$0.035 \times \$48,000$	\$ 1,700
Amortization	$0.00763 \times \$48,000$	370
	Maintenance	
Revetment,	52 tons @ \$8.00	420
Slope protection,	11 tons @ \$8.00	<u>90</u>
	Total Annual Charges	\$ 2,580

5. Mara Vista. - The plan of protection consists of construction of 1,900 feet of concrete walls on the seaward side of Menauhant Road.

a. Total First Cost

Concrete walls, 1,900 feet long, 520 cu. yds. @ \$40.00	\$24,000 *
Engineering & Design	<u>2,000</u>
Subtotal	\$26,000
Supervision & Administration	<u>2,000</u>
Total First Cost	\$28,000

*Includes Contingencies

b. Total Annual Charges

Interest $0.035 \times \$28,000$	\$ 1,000
Amortization $0.00763 \times \$28,000$	200
Maintenance, wall repairs	<u>300</u>
Total Annual Charges	\$ 1,500

6. Acapesket. - The plan of protection and improvement consists of beach widening by direct placement of sand fill, and the enlargement and extension of four groins.

a. Total First Cost

Groins, 11,600 tons stone @ \$8.00	\$106,500 *
Beach fill, 100,000 cu. yds. @ \$1.25	<u>143,500</u>
Subtotal	\$250,000
Engineering & Design	<u>8,000</u>
Subtotal	\$258,000
Supervision & Administration	<u>20,000</u>
Total First Cost	\$278,000

*Includes Contingencies

b. Total Annual Charges

Interest $0.035 \times \$278,000$	\$ 9,700
Amortization $0.00763 \times \$278,000$	2,100
Maintenance	
Groin repairs, 116 tons stone @ \$10.00	1,200
Beach fill, 1,700 cu. yds. @ \$ 1.50	<u>2,600</u>
Total Annual Charges	\$15,600

7. Davisville. - The plan of protection and improvement consists of beach widening by direct placement of sand fill and construction of one new jetty and two new groins.

a. Total First Cost

Jetty and two groins,	9,700 tons stone	@ \$8.00	\$ 89,300 *
Beach fill,	60,000 cu. yds.	@ \$1.40	<u>96,700</u> *
	Subtotal		\$186,000
Engineering & Design			<u>6,000</u>
	Subtotal		\$192,000
Supervision & Administration			<u>15,000</u>
	Total First Cost		\$207,000

*Includes Contingencies

b. Total Annual Charges

Interest $0.035 \times \$207,000$	\$ 7,250
Amortization $0.00763 \times \$207,000$	1,580
Maintenance	
Jetty and groins repairs,	
97 tons stone @ \$10.00	970
Beach fill, 1,200 cu. yds. @ \$ 1.50	<u>1,800</u>
Total Annual Charges	\$11,600

8. Menauhant. - The plan of protection and improvement consists of beach widening by direct placement of sand fill, the enlargement of three groins, and the construction of 1,500 feet of concrete wall on the seaward side of Menauhant Road.

a. Total First Cost

Groins, 3,100 tons stone @ \$12.00	\$ 42,200 *
Beach fill, 74,000 cu. yds. @ \$ 1.35	114,100 *
Concrete wall, 1500 ft. long, 420 cu. yds. concrete @ \$40.00	<u>19,100 *</u>
Subtotal	\$175,400
Engineering & Design	<u>5,300</u>
Subtotal	\$180,700
Supervision & Administration	<u>14,300</u>
Total First Cost	\$195,000

*Includes Contingencies

b. Total Annual Charges

Interest $0.035 \times \$195,000$	\$ 6,800
Amortization $0.00763 \times \$195,000$	1,400
Maintenance	
Groin repairs, 31 tons stone @ \$12.00	400
Beach fill, 1,800 cu. yds. @ \$ 1.50	2,700
Wall repairs	<u>200</u>
Total Annual Charges	\$11,500

APPENDIX J

BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF FALMOUTH, MASSACHUSETTS

INFORMATION CALLED FOR BY SENATE RESOLUTION 148,
85TH CONGRESS, ADOPTED 28 JANUARY 1958

1. The study covers the south or Vineyard Sound shore of Falmouth, Massachusetts, between Nobska Point and Waquoit Bay. The problem consists of erosion of bluffs and beaches and storm damages to low shore roads and coastal development from wave attack. The shore is exposed to wave attack from the Atlantic Ocean across Vineyard and Nantucket Sounds through limited openings between offshore islands. The mean range of tide varies from 1.1 to 1.5 feet. The highest tide of record of 12.7 feet above mean low water occurred at Falmouth Heights during 14-15 September 1944.

2. Improvements Considered. - Plans were developed for protection and improvement of shore areas as follows:

a. Between Nobska Point and Falmouth Beach. - Construct stone mounds or stone revetment wherever needed for bluff protection.

b. Between Falmouth Inner Harbor and Bluffs at Falmouth Heights. - Widen 1,000 feet of beach by direct placement of sand fill, lengthen Falmouth Harbor East Jetty to 250-foot length, enlarge and lengthen existing groin to 250-foot length.

c. Falmouth Heights Bluffs. - Place additional riprap revetment along the toe of approximately 1,450 feet of wall, place stone revetment on approximately 750 feet of slope above the wall and control surface runoff wherever needed.

d. Mara Vista. - Construct low walls, approximately 1,900 feet long along the seaward side of the shore road.

e. Acapesket. - Widen 1,300 feet of beach by direct placement of sand fill, enlarge and lengthen four (4) existing groins to 345 to 510-foot lengths.

f. Davisville. - Widen 1,500 feet of beach by direct placement of sand fill, construct a jetty 530 feet long and two groins 340 and 510 feet long.

g. Menauhant. - Widen 1,600 feet of beach by direct placement of sand fill, enlarge and lengthen three (3) existing groins to 240 to 280 foot lengths.

In addition, general methods of protection and improvement were considered for other areas which did not merit development of detailed plans. These methods consisted of maintenance of existing protective works, construction of additional similar structures, reconstruction or relocation of low shore roads at higher elevations, placement of stockpiles of sand along the shore to nourish beaches and location of future developments at a high enough elevation or sufficiently landward to minimize damaging wave attack. A number of low barrier bars fronting ponds are considered generally unsuitable for residential development, due to their low elevation and vulnerability to overtopping and damages during severe storms and hurricanes. Complete protection of low areas by high seawalls or other barriers is not warranted by the limited developments which would benefit.

3. Conclusions and Recommendations. - Due to the adequacy of public beach areas for present recreational use, the lack of information to indicate the need for additional area for prospective use, the small value of benefits to be derived from protecting public roads and public lands or the private ownership and consequent private benefits to be derived from protecting private property, the public interest, as required by Public Law 826, 84th Congress, is insufficient to warrant Federal participation in the cost of the projects considered. Therefore, it was recommended that no projects be adopted by the United States for the protection or improvement of the shores of Falmouth, Massachusetts. It was further recommended that protective measures which may be undertaken by local interests, based upon their determination of economic justification, be accomplished in accordance with plans and methods considered in the study. Estimated first costs of considered improvements, all non-Federal, are listed as follows:

<u>Location</u>	<u>Improvement</u>	<u>Estimated First Cost</u>
Between Nobska Point and Falmouth Beach	Stone mound and slope protection	\$81.00 per linear foot.
Falmouth Heights (West End)	Groin and jetty enlargement and beach fill	89,000
Falmouth Heights (Central Portion)	Stone revetment and slope pro- tection	48,000
Mara Vista	Concrete wall	28,000
Acapesket	Enlargement of 4 groins and beach fill	278,000
Davisville	Construction of jetty, 2 groins and beach fill	207,000
Menauhant	Enlargement of 3 groins, beach fill and con- crete wall	195,000

4. Discussion. - The economic justification for construction of the considered projects has not been determined. Benefits were not evaluated since benefits to be derived are principally private and not of a type to make the improvements eligible for Federal aid under existing Federal policy. Changing the economic life of the projects would not change the findings of the study in so far as they pertain to eligibility for Federal aid.

APPENDIX L

REPORT OF THE UNITED STATES FISH AND WILDLIFE SERVICE

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
59 Temple Place
Boston 11, Massachusetts

March 4, 1963

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

This is our conservation and development report on the beach erosion control plans for Falmouth, Massachusetts, as described in the letter dated September 12, 1962, and accompanying maps, from the Deputy Division Engineer. This report was prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), in cooperation with the Massachusetts Division of Marine Fisheries and Division of Fisheries and Game, who indicated their concurrence by letters dated December 18, 1962 and December 19, 1962, respectively.

We understand that there are several methods under consideration for correction of beach erosion. The plans under consideration are:

1. Between Nobska Point and Falmouth Beach: Construct stone mounds or stone revetments wherever needed for bluff protection.
2. Between Falmouth Inner Harbor and Bluffs at Falmouth Heights: Widen 1,000 feet of beach by direct placement of sand fill, lengthen Falmouth Harbor East Jetty to 250-foot length, enlarge and lengthen existing groin to 250-foot length.
3. Falmouth Heights Bluffs: Place additional riprap revetment along the toe of approximately 1,450 feet of wall, place stone revetment on approximately 750 feet of slope above the wall and control surface runoff wherever needed.
4. Mara Vista: Construct low walls, approximately 1,900 feet long along the seaward side of the shore road.
5. Acapesket: Widen 1,300 feet of beach by direct placement of sand fill, enlarge and lengthen four existing groins to 345 to 510-foot lengths.
6. Davisville: Widen 1,500 feet of beach by direct placement of sand fill, construct a Jetty 530 feet long and two groins 340 and 510 feet long.
7. Menauhant: Widen 1,600 feet of beach by direct placement of sand fill, enlarge and lengthen three existing groins to 240 to 280-foot lengths.

The project works would be situated in areas of biological significance. Quahogs, soft-shelled clams, and bay scallops are produced in the salt-water ponds and support a commercial and recreational shellfishery of considerable significance. Finfish resources in the area support a highly valued sportfishery; the species of primary importance are striped bass, bluefish, winter flounder, northern scup, and tautog. The existing groins or jetties which will be affected by the project will provide 24,000 fisherman-days annually, having a value of \$36,000. Waterfowl use of the salt ponds is moderate during migration and wintering periods; the black duck and Canada goose are common migrants and winter residents. Other waterfowl species and shorebirds use the ponds in varying concentrations.

In Falmouth Inner Harbor quahogs are produced on about seven acres of underwater lands. Because of heavy pollution, shellfishing is not permitted. However, seed and adult quahogs are transplanted to unpolluted waters from this area. The 10-year average annual quahog seed stock transplanting program has been 1,000 bushels; up to 4,000 bushels have been transplanted per year under a State-operated program. The town received from \$2 to \$12 a bushel for transplant stock, depending upon graded sizes. The present town transplanting program has a potential for expansion if additional funds are appropriated. Limited scallop and soft-shelled clam resources are present but are not utilized because of pollution.

There are quahog, scallop, and soft-shelled clam resources in Great Pond. (See plate II). The town shellfish officer estimates that between \$50,000 and \$60,000 worth of shellfish were harvested from the pond in 1961. Scallops can be taken only by family-permit holders; quahogs and soft-shells can be taken by both recreational and commercial shellfishermen.

Bournes Pond provides an estimated \$25,000 to \$30,000 worth of shellfish annually. Quahogs, soft-shelled clams, and scallops are harvested primarily by recreational diggers. Commercial shellfishing is limited. Excessive shoaling and unstable bottom have eliminated a sizeable portion of the lower pond for shellfish production.

Dredging offshore or from inland borrow pits to obtain beach fill would not have any significant effect upon fish and wildlife resources. Dredging from the ponds behind the beaches would be damaging to the resources if fill were removed from certain areas; if dredging were limited to areas as described below and as shown on attached plates I, II, and III, it would enhance habitat conditions and improve the potential for utilization of the finfishery and shellfishery.

If it becomes necessary to dredge in Falmouth Inner Harbor, beach fill could be dredged in the lower harbor to an east-west line, 1,100 feet from the town beach, without causing significant damages to the shellfish habitat or resources. (See plate I). The town should be notified 90 days in advance of dredging operations to permit removal of quahogs for transplanting. Dredging should be done between October 1 and January 1 to minimize siltation damages to spawning shellfish and winter flounder in this and any of the ponds of significance to shellfish or waterfowl which are discussed below.

It would be important, also, to insure that channel dredging in each pond entrance be done in a way that will provide a continuous channel through the offshore shoaling, thus permitting unimpeded interchange of waters between the ponds and the sound.

If dredging becomes necessary in Great Pond, damages to shellfish habitat would be insignificant provided it conforms to patterns described in plate II. The marsh islands near the pond entrance should be avoided. Their continued presence contributes to maintenance of nutrient supplies in the pond area. The town should be notified 90 days in advance of dredging operations to permit removal of quahogs for transplanting to other areas of the same pond. Conditions would be improved for utilization of the fishery for striped bass, bluefish, winter flounder, summer flounder, scup, and tautog.

Dredging would cause no significant damage to shellfish habitat in Bournes Pond if it is done in the area shown on plate III. Dredging would eliminate the shoal, allow for a greater interchange of waters between the Sound and the pond, and possibly provide improved habitat for quahogs and scallops.

There will be no significant effect upon shellfish habitat if dredging is done in Green Pond. Marsh habitat of special value to shorebirds however, would be destroyed if the southwestern and western shores of Green Pond were dredged; these areas should be preserved. Spoil which is excess to that needed for construction should not be deposited on marsh habitat.

The construction of stone mounds or stone revetments and offshore dredging will have no detrimental effect upon fish and wildlife habitat or resources. The lengthening of existing groins and jetties, and construction of new groins and jetties, will have no harmful effects upon the resources, and will tend to stabilize the beach-sand littoral drift and stabilize bottom conditions within the ponds, thus possibly extending shellfish and waterfowl habitat. Lengthened groins and jetties would provide an estimated 63,000 fisherman-days per year, a net increase of 39,000 fisherman-days, representing a benefit of \$58,500.

There is an opportunity to further increase the sportfishery benefits of the project. This would involve (1) modification of the groins and jetties to hold the top elevation to within a six-inch vertical variation and chink gaps in the top surface to provide a safe walking surface, and (2) provision of adequate parking facilities. Due to access possibilities and use-potential, this would be most applicable on the groins and jetties listed below. We have numbered the groins and jetties for easy reference:

<u>Structure No.</u>	<u>Designation, location</u>
1	Falmouth Harbor east jetty
2	Groin 1,200 feet east of Falmouth Harbor
3	Groin 1,000 feet west of Green Pond
4	Groin 1,400 feet east of Green Pond east jetty
5	Groin 1,700 feet east of Green Pond east jetty
6	Bournes Pond west jetty
7	Groin 2,100 feet west of Eel Pond entrance
8	Groin 1,450 feet west of Eel Pond entrance
9	Groin 750 feet west of Eel Pond entrance

There is potential for added fishing opportunities at the Falmouth Harbor east jetty and the groin located 1,200 feet east of Falmouth Harbor, structures numbers 1 and 2, respectively. Winter flounder and tautog are fished from both structures; bluefish and striped bass provide added fishing from the jetty. The town owns the land from which the groin and jetty extend seaward.

Groin number 3, 1,000 feet west of Green Pond and groins numbers 4 and 5, 1,400 feet and 1,700 feet, respectively, east of the Green Pond east jetty also offer potential for improved fishing opportunity. Groins numbers 4 and 5 extend seaward from town-owned land and fisherman access is possible from the land end. The Bournes Pond west jetty, number 6, would offer improved fishing opportunity for bluefish, striped bass, winter flounder, tautog, and northern scup. Because the landward end is on private property, fisherman access is gained from the beach.

The two groins, numbers 7 and 8, between Bournes Pond and Eel Pond, are accessible from town-owned beach. Access to groin number 9, 750 feet west of Eel Pond, can be gained from the abutting roadway.

It is estimated that the fisherman use would amount to an average of 85,000 fishermen days annually during the project life if the structures were modified as previously described, and if adequate parking facilities are provided. This is an increase of 22,000 fisherman-days annually over the with-the-project conditions. This benefit is valued at \$33,000. Table 1 summarizes the average annual fisherman-days for each groin or jetty over the life of the project, without the project, with the project, and with the modified project, i.e. with parking areas and smooth surfaces on the jetties and groins.

Table 1. Estimated average annual fisherman use (fisherman-days)

<u>Groin or jetty</u>	<u>Without the project</u>	<u>With the Project</u>	<u>With the Modified Project</u>
1	6,900	12,400	16,800
2	500	7,200	9,700
3	700	13,500	18,100
4	0	5,500	7,400
5	0	5,500	7,400
6	0	5,000	6,700
7	5,500	3,000	4,000
8	3,700	3,500	4,700
9	6,900	7,400	10,200
	<hr/>	<hr/>	<hr/>
Rounded	24,000	63,000	85,000

Parking area capacities needed are shown in table 2. Parking areas for two or more structures may be combined. They should be constructed on the land side of the road. Marsh areas should not be filled to provide parking areas if convenient parking facilities can be provided elsewhere.

Table 2. Parking area requirements

<u>Groin or jetty</u>	<u>Number of cars</u>
1	30
2	20
3	30
4	15
5	15
6	10
7	10
8	10
9	20

The implementation of the following recommendations will provide increased sport fishing opportunities and will minimize damages to the resources. In view of the fact that the increased benefits from the sportfishery would accrue to the public at large rather than to any identifiable segment of the public, the sport fishing facilities and the required parking facilities should be a non-reimbursable Federal cost of the project.

We recommend--

1. That necessary beach fill materials be obtained from Falmouth Inner Harbor as indicated on plate I; the town be notified 90 days prior to starting dredging activities to permit removal of quahog stocks from the dredge site.

2. That necessary beach fill materials be obtained from Great Pond as indicated on plate II; the marsh islands be avoided.

3. That the town be notified 90 days prior to dredging activities to permit removal of quahogs for transplanting elsewhere in Great Pond.

4. That dredging be done between October 1 and January 1 in any pond of indicated significance to shellfish or waterfowl.

5. That dredging activities in Bournes Pond be done in the area shown on plate III.

6. That dredging of the marshy area along the western and southwestern shores of Green Pond be avoided.

7. That groins and jetties listed above be constructed with the top elevations held to within a 6-inch vertical variation and to gaps in the top surface chinked to within a 6-inch opening to provide a safe walking surface for fishermen.

8. That adequate parking areas for fishermen be provided as described above.

9. That dredging necessary to obtain beach fill be done in such manner that the seaward end of each channel be dredged through the offshore shoaling at the pond entrances to provide a continuous channel.

10. That spoil which is in excess of that needed for construction not be deposited on marshlands.

11. That, if the project is recommended for Federal construction, the cost of providing parking areas and smooth surfaces on groins and jetties for sportfisherman-use be a non-reimbursable Federal cost of the project.

Sincerely yours,

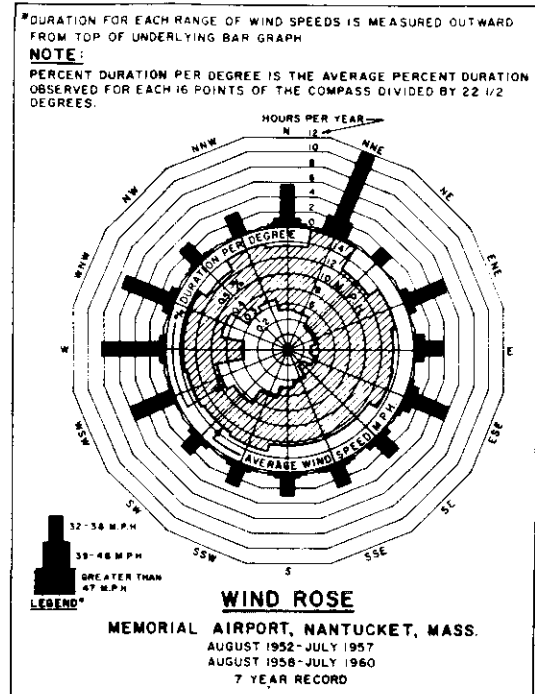
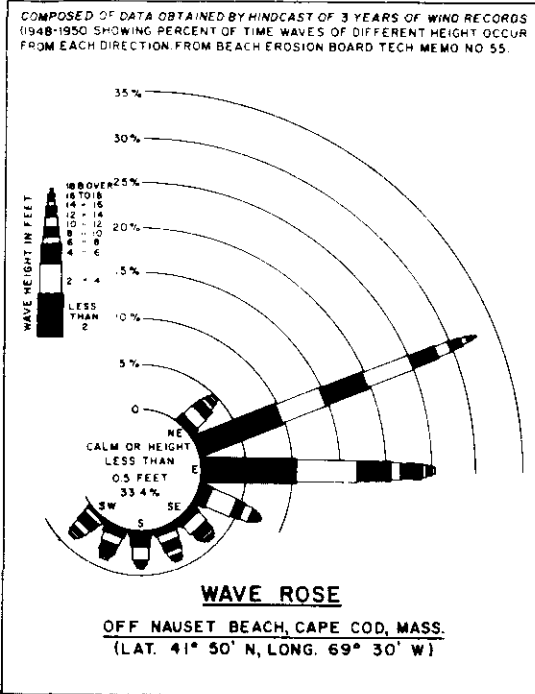
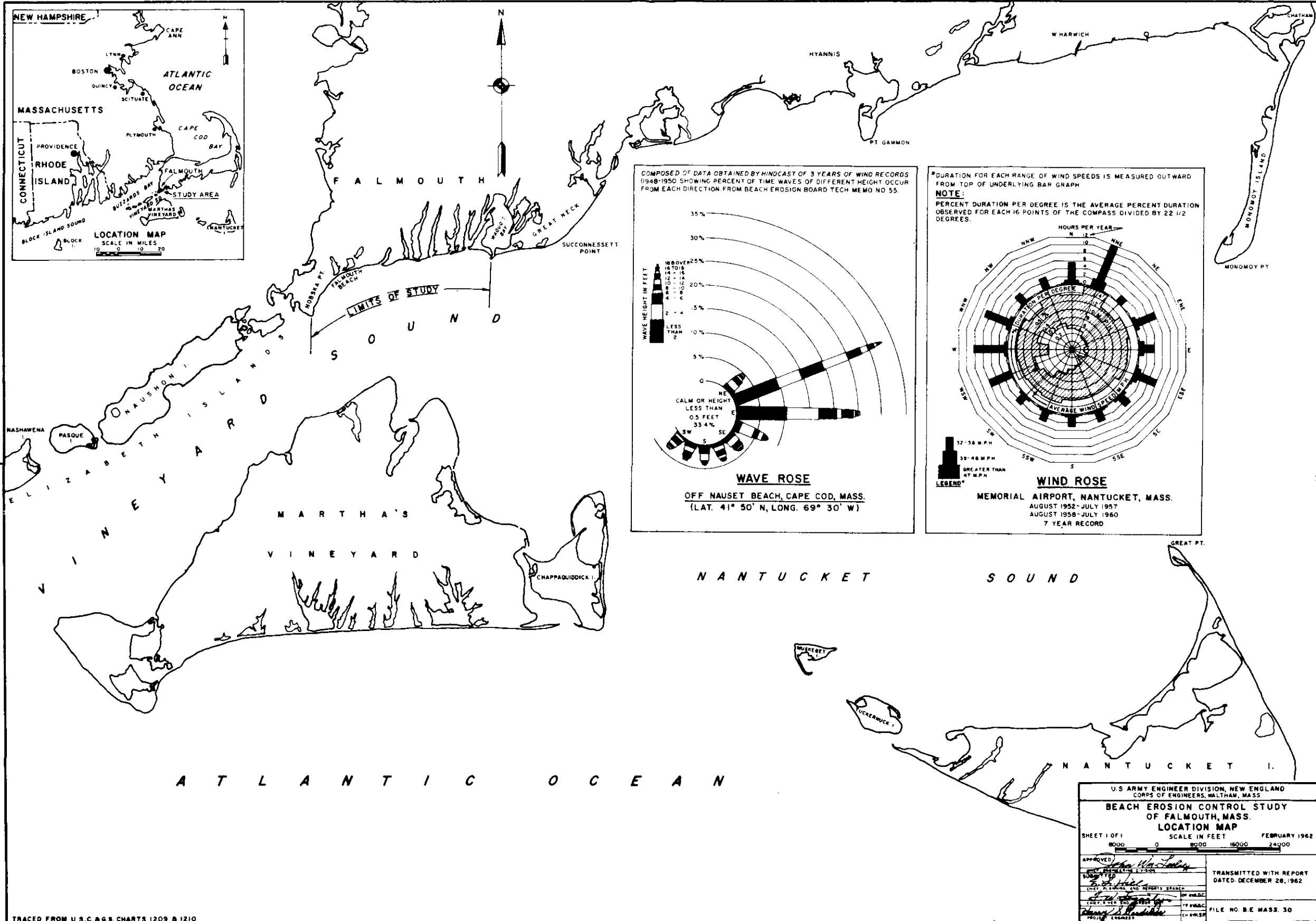


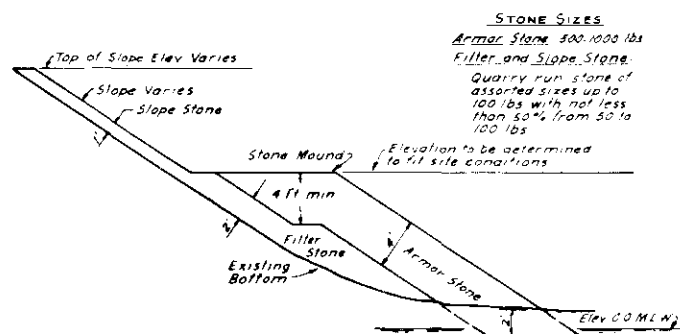
John S. Gottschalk
Regional Director
Bureau of Sport Fisheries & Wildlife



John T. Gharrett
Regional Director
Bureau of Commercial Fisheries

○



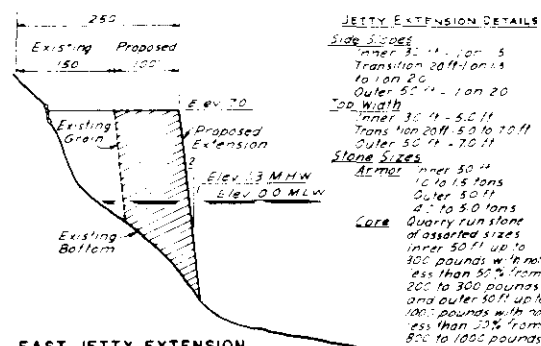
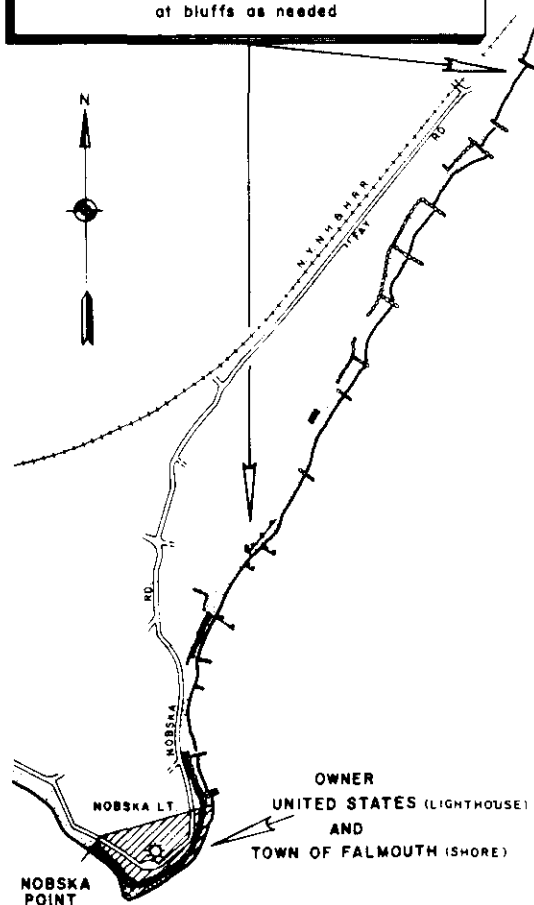


SCALE IN FEET
 0 5 10 15

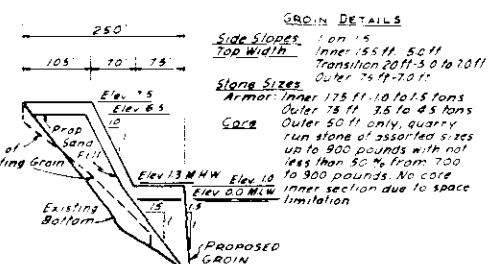
TYPICAL SECTION OF PROPOSED STONE PROTECTION
 FOR BLUFFS EAST OF NOBSKA POINT

**IMPROVEMENT FOR CONSIDERATION
 OF LOCAL INTERESTS**

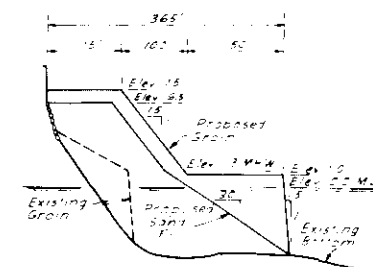
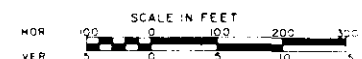
Stone mounds and slope revetment
 at bluffs as needed



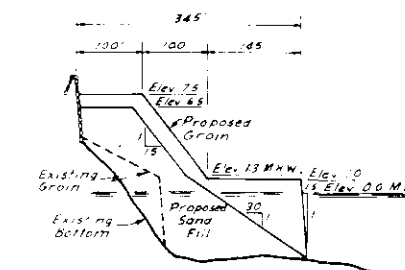
EAST JETTY EXTENSION

GROIN RECONSTRUCTION
AND SAND FILL

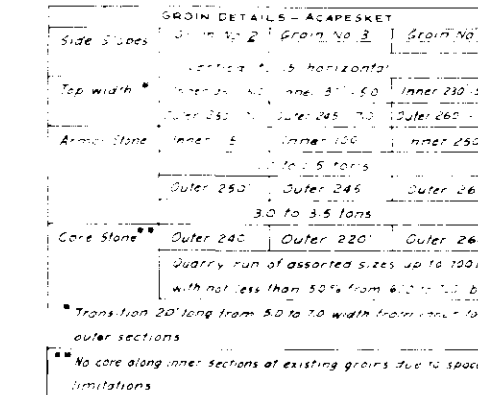
PROFILES OF PROPOSED EAST JETTY EXTENSION
 GROIN RECONSTRUCTION AND SAND FILL AT FALMOUTH HEIGHTS



GROIN NO. 2 (NO. SIMILAR)

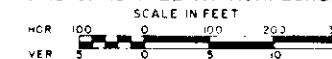


GROIN NO. 3



GROIN NO. 4

PROFILES OF PROPOSED GROIN RECONSTRUCTION
 AND SAND FILL AT ACAPESKET



**IMPROVEMENT FOR CONSIDERATION
 OF LOCAL INTERESTS**

Widen 1000 feet of beach by
 direct placement of sand fill
 Enlarge groin and jetty to 250 foot lengths

**IMPROVEMENT FOR CONSIDERATION
 OF LOCAL INTERESTS**

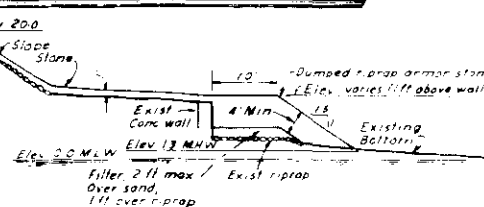
Additional riprap revetment along toe
 of 1450 feet of wall as needed
 Additional stone slope revetment above wall
 as needed
 Control surface runoff

**IMPROVEMENT FOR CONSIDERATION
 OF LOCAL INTERESTS**

Low walls 1900 feet long along shore road

**IMPROVEMENT FOR CONSIDERATION
 OF LOCAL INTERESTS**

Widen 1300 feet of beach by
 direct placement of sand fill
 Enlarge four (4) groins to
 345-365, 510 foot lengths

TYPICAL SECTION OF PROPOSED STONE
PROTECTION AT FALMOUTH HEIGHTS

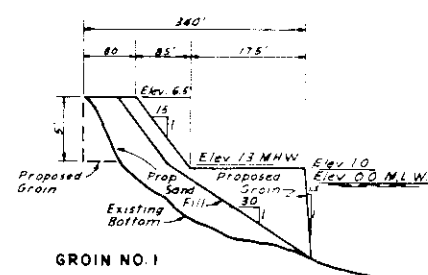
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
 CORPS OF ENGINEERS, WALTHAM, MASS.

**BEACH EROSION CONTROL STUDY
 OF FALMOUTH, MASS.**

PLANS OF PROTECTION

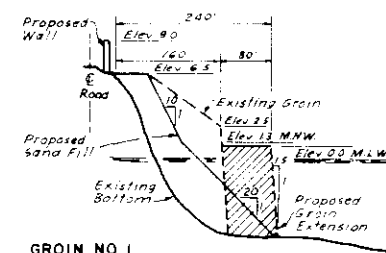
SHEET 1 OF 2
 SCALE IN FEET
 0 500 1000 1500

APPROVED: *John W. Bailey*
 SUBMITTED: *John W. Bailey*
 CHECKED: *John W. Bailey*
 DESIGNED: *John W. Bailey*
 DRAWN: *John W. Bailey*
 TRANSMITTED WITH REPORT
 DATED DECEMBER 28, 1962
 FILE NO. 8 E MASS. 35



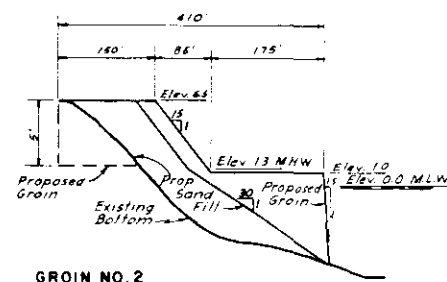
GROIN NO. 1

GROIN AND JETTY DETAILS-DAVISVILLE			
	Groin No. 1	Groin No. 2	Jetty
Side Slopes	Vertical to 1.5 horizontal		
Top Width	Inner 145 - 50'	Inner 195 - 50'	Inner 320 - 50'
	Outer 175 - 30'	Outer 195 - 70'	Outer 210 - 70'
Armor Stone	Inner 145	Inner 215	Inner 320
	Outer 175	Outer 195	Outer 210
	10 to 1.5 tons	3.5 to 4.5 tons	
Core Stone	Inner 165	Inner 215	Inner 320
	Outer 175	Outer 195	Outer 210
	Quarry run of assorted sizes up to 350 lbs with not less than 50% from 200 to 300 lbs.	Quarry run of assorted sizes up to 900 lbs with not less than 50% from 700 to 900 lbs.	Quarry run of assorted sizes up to 900 lbs with not less than 50% from 700 to 900 lbs.
	Transition 20' long from 50' to 10' width from inner to outer sections		

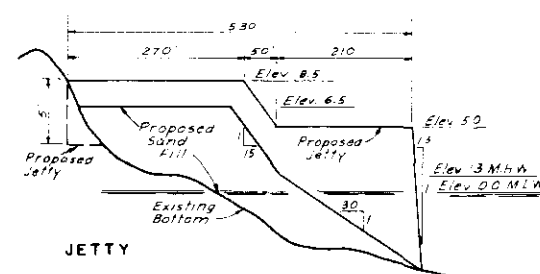


GROIN NO. 1

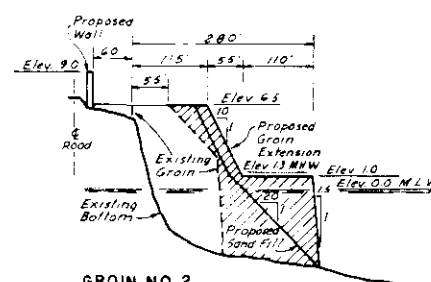
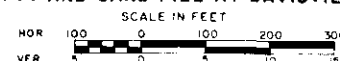
GROIN DETAILS-MENAUHANT			
	Groin No. 1	Groin No. 2	Groin No. 3
Side Slopes	Vertical to 1.5 horizontal		
Top Width	Inner 35 - 50'	Inner 35 - 50'	Inner 40 - 50'
	Outer 60 - 70'	Outer 225 - 70'	Outer 210 - 70'
Armor Stone	Inner 35	Inner 55	Inner 60
	Outer 60	Outer 225	Outer 210
	1.0 to 1.5 tons	3.5 to 4.5 tons	
Core Stone	Outer 80	Outer 150	Outer 70
	Quarry run of assorted sizes up to 900 lbs with not less than 50% from 700 to 900 lbs.		
	Transitions 20' long from 50' to 10' width from inner to outer sections		
	No core along inner sections of existing groins due to space limitations		



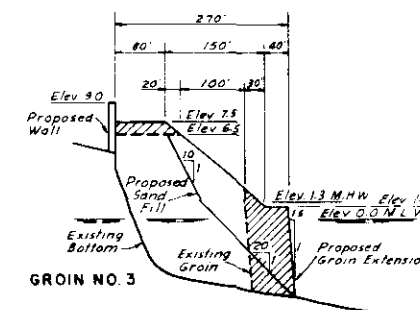
GROIN NO. 2



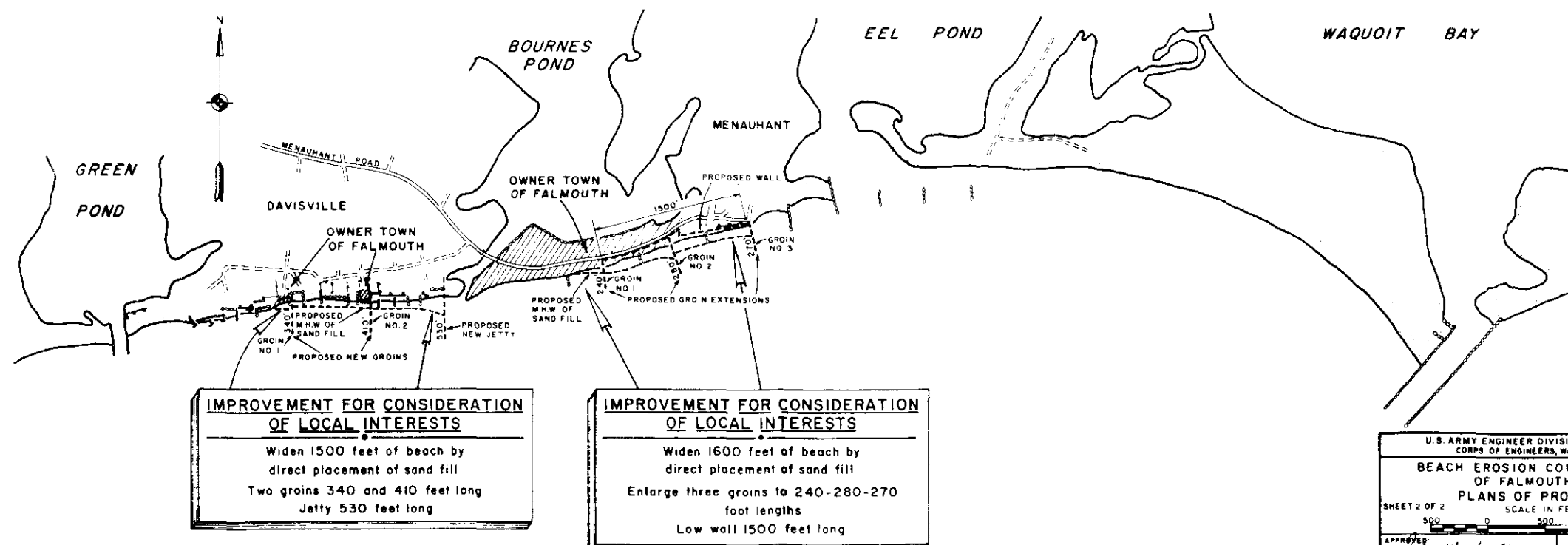
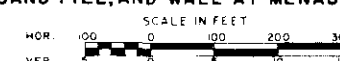
JETTY

PROFILES OF PROPOSED GROINS
JETTY AND SAND FILL AT DAVISVILLE

GROIN NO. 2



GROIN NO. 3

PROFILES OF PROPOSED GROIN RECONSTRUCTION
SAND FILL, AND WALL AT MENAUHANT

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND CORPS OF ENGINEERS, WALTHAM, MASS.	
BEACH EROSION CONTROL STUDY OF FALMOUTH, MASS.	
PLANS OF PROTECTION	
SHEET 2 OF 2	NOVEMBER 1962
SCALE IN FEET 0 500 1000 1500	
APPROVED <i>[Signature]</i> SUBMITTED <i>[Signature]</i>	TRANSMITTED WITH REPORT DATED: DECEMBER 28, 1962
CHECKED BY <i>[Signature]</i> CORP. ENGINEER	FILE NO. B.E. MASS 35